Boeing’s Laser Multiplex System

Group 34
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Motivation
Objective

- The system can have both the accuracy of laser projectors and the speed of optical projectors

- A projection system that uses two laser projectors to display animation

- A calibration system to detect correct alignment of the two projectors
Calibration Unit

- Test pattern sent to projectors
- Shine laser on sensing circuit
- Signal output to the microcontroller
- Analyzed data to the computer
- Results display on the monitor
Photodiode Sensing Circuit

- 5V, 12V and -12V power in
- Photodiodes produce current
- 16 analog signals send to microcontroller
Photodiode Circuit Schematic

- Decoupling capacitor = 1uF
- 1k resistor protecting photodiode
- Cut-off frequency 8.8 Hz
- Voltage amplifier with DC gain =30
- Buffer stage
Limitation - Resolution

- Minimum detected length is 0.4 inch
- Maximum detected area is $0.4 \text{ inch} \times 0.4 \text{ inch} = 0.16 \text{ inch}^2$
Voltage Output under Natural Light with DC Block

The voltage is around 0.01V.
Cross-Section Boards Reduce Laser Effect

\[ V_{\text{affect}} = 2.5\text{V} \quad V_{\text{affect-new}} = 0.41\text{V} \]
Voltage Output When Laser Shining On

\[ V_{laser} = 3.563V \]
Processing Unit

- Consists of three PIC18F4550 chips
- The 16 analog outputs are connected to two of the PICs (13 outputs to 1\textsuperscript{st} PIC; 3 outputs to 2\textsuperscript{nd} PIC)
- The 3\textsuperscript{rd} PIC – provides a square wave with a frequency of 0.25Hz (named Clk) to the two PICs
Cont.

- The PICs count the total number of transitions from logic 0 to logic 1 when Clk is high for each analog input.
- Threshold voltage were all set at 3.4 V.
- However, each output from photodiodes has different voltage level (with laser presence or without laser).
Why count transitions?

- Because the lasers will be tracing a pattern at some frequency
- In order for this to work:
  - The two lasers should trace a same pattern
  - One of the lasers should trace at a frequency which is a multiple of the other laser’s frequency
  - They should start tracing at different starting coordinates
After number of transitions are known, the corresponding case is determined:

- Case 1: laser 1 traced through
- Case 2: laser 2 traced through
- Case 3: both lasers traced through
- Case 4: no laser traced through

A variable is used to store the result for each photodiode.
Between Processing Unit and PC

- 8 bit/ asynchronous mode
- 9600 baud rate
- 19 bytes of data
- Start byte: 0xff
  - Next 16 bytes: 4 bits(coordinates)
    - 4 bits(case result)
  - 18th byte: 0x00 or 0x01 (indicate if aligned)
- Last byte: 0xff
MAX232 is used to convert UART data such that the data can be read by a standard RS232-port.
## Serial Port Data Convention

<table>
<thead>
<tr>
<th>Start Byte</th>
<th>Color Byte 1 to 16</th>
<th>Status Byte</th>
<th>Stop Byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xff</td>
<td><em>See Interpretation</em></td>
<td>0x01 or 0x00</td>
<td>0xff</td>
</tr>
</tbody>
</table>

**Color Byte Interpretation:**
- Higher 4 bits represents the number of photodiode
- Lower 4 bits represents the lighting condition of the current photodiode
  0000 = Grey: No laser light is shining on the current photodiode
  0010 = Green: Both lasers are projecting on the current photodiode
  0100 = Blue: Only laser 2 is projecting on the current photodiode
  1000 = Red: Only laser 1 is projecting on the current photodiode
Limitation

- Cannot precisely control the scanning frequency of the Laser projector by software
- Each laser projector does not exhibit identical refresh rate at each time
- One of the newer model have significantly larger refresh rate than the older one

Therefore, two laser projectors have to be calibrated separately.
Graphical User Interface

Setting up Serial Port Connection
Graphical User Interface

Laser Projector 1 is aligned correctly
Graphical User Interface

Laser Projector 2 is misaligned
Accomplishments

- A Calibration unit that helps align two laser projectors
- Control the laser projectors through a PC using a JAVA API
Application:
Assembly Instruction Animation
Credits

- Professor P. Scott Carney
- Jane Tu
- Parts Shop Personnel
- Alex Suchko
- Philip Freeman, Phillip Tillman & Kenneth Owens from the Boeing Company
thank you!