Creating DNA From Scratch For DNA-Based Data Storage

SDDEC22-12

Team Members: Nathan Armstrong, Lucas Heimer, Connor Larson, Kyle Riggs, Brandon Stark

Faculty Advisor: Meng Lu

Client: Iowa State University

Problem Statement

- Problem: Increasing demand for data storage with limited space
- Solution: Printed DNA data sequences for data storage

Functional Requirements

- Method to selectively pass UV light to channel (LCD)
- Control of all components from single program
- Capacity to perform DNA synthesis

Engineering Constraints

- Accuracy of DNA sequences
- Control of LCD via HDMI
- Ability to dynamically change matrix sizes
- Pressure limitation of microfluidic system

System Users & Uses

- Geneticists - Study DNA sequencing and disease research
- Data Analysts - Utilize compact storage for digital data

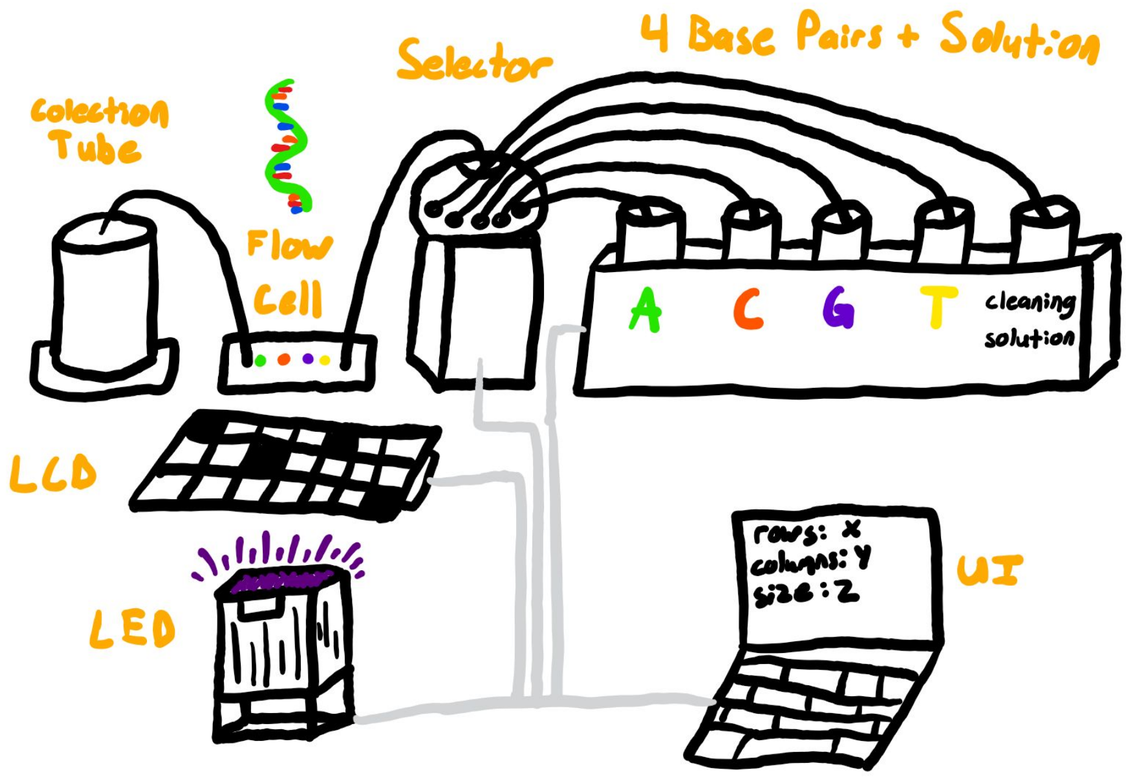
Non-Functional Requirements

- Develop new medium of data storage
- Efficient and accurate system
- Customizable options for user

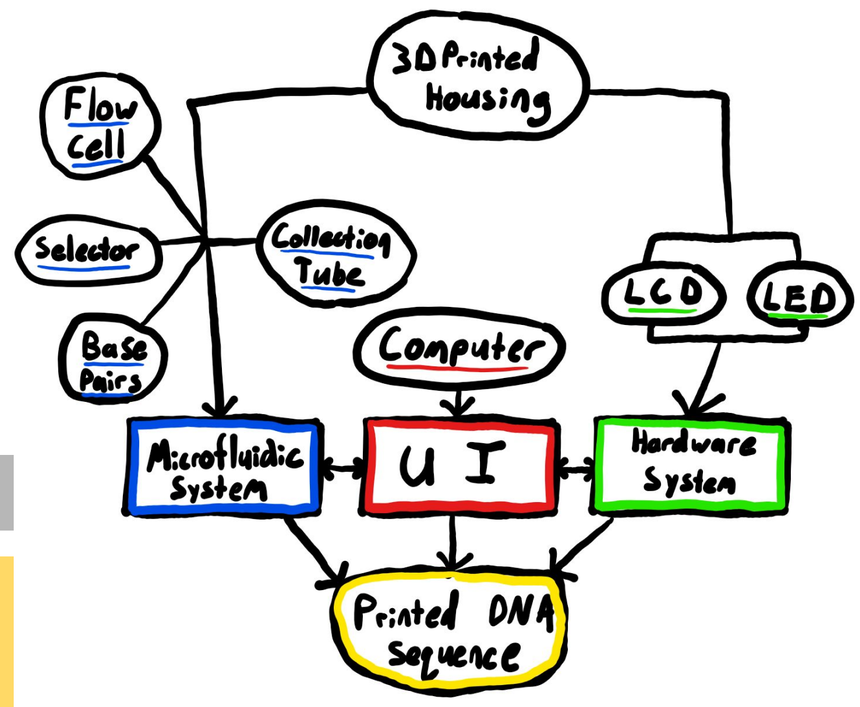
Applicable Engineering Standards

IEEE 260.1 - Standard Letter Symbols for Units of Measurement
IEEE 830 - Software Requirements Specifications
IEEE 1588 - Precision Time Protocol
IEEE 802.6 - Standards for information exchange between systems
IEEE 1074 - Software Development Life Cycle
IEEE 1471 - Software Architecture / System Architecture

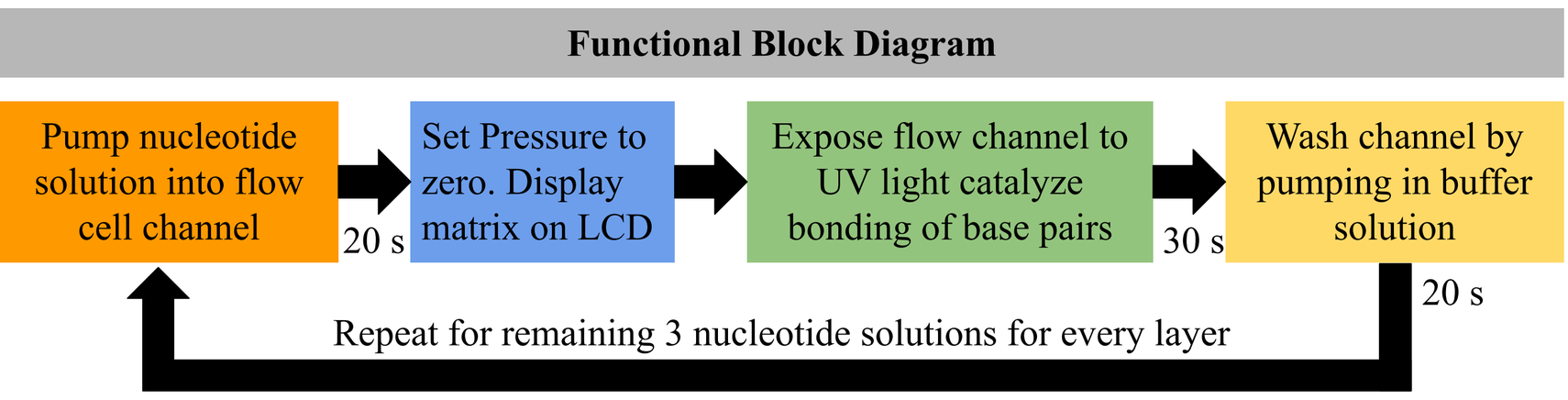
Concept Sketch



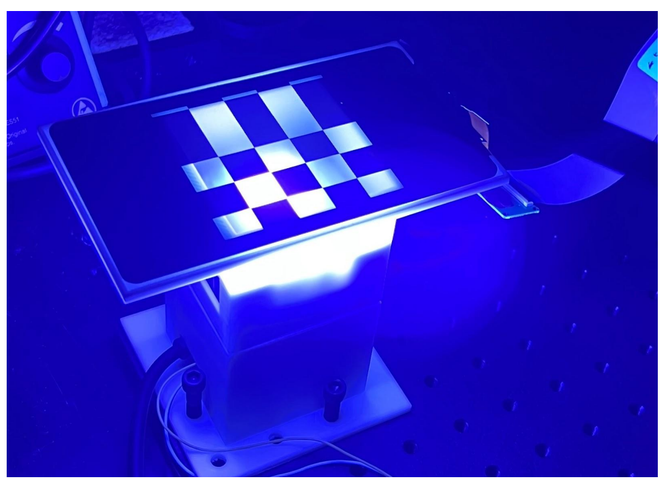
System Block Diagram

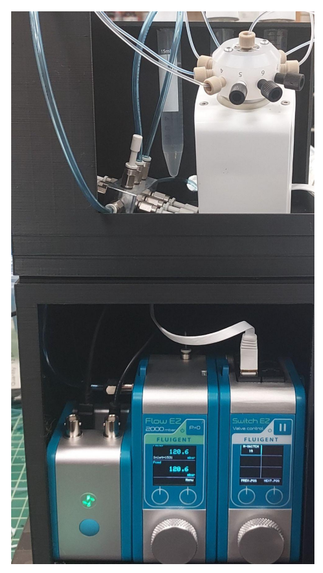


Functional Block Diagram



Functional Systems





Technical Details - LCD/LED

- Automated process to control when the LED light turns on/off
- LCD screen stays on when system is on
- Secure housing on the THOR board

Testing Procedure - LCD/LED

- UV light intensity
- Heat dissipation testing
  - Different fluids
  - Various glass thicknesses
  - Dynamic vs. static heat dissipation
- LED trigger
- LCDs with/without diffusers
- LCD resolution
- Photolithography masks

Technical Details - User Interface

- Can be modified for user to control/automate several parts of the system
- Display matrix window to LCD w/ correct dimensions
- Pre-set DNA sequences

Testing Procedure - User Interface

- Windows Presentation Foundation real-time updates
  - Matrix dimensions
  - Cell sizes
  - UI design
- DNA Sequence printing
  - Breakpoints in Sequence split calculation
  - Varied delays

Technical Details - Microfluidic System

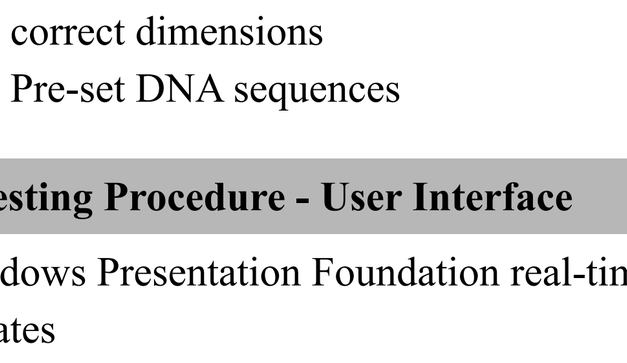
- Sequentially pumps reagents to flow channel
  - Intermediate buffer solution to clean channel
- Reactions catalyzed based on state of LED source
  - Exposure time of ~25 seconds required
- All components controlled via Fluigent Library integrated into UI

Testing Procedure - Microfluidic System

- Burst pressure
- Flow rate
- Exposure time
- Time from reservoir to channel

Test Results

Photoresist Test # (Left → Right)	UV Light Values
1	3.5 Amps @ 100%
2	3.5 Amps @ 100%
3	2.625 Amps @ 75%
4	1.75 Amps @ 50%



Parameter	Measured Value
Burst Pressure	150 mbar
Flow Rate	33.33 µl/s
Exposure Time	30 s
Time from Reservoir to Channel	20 s