



Creating DNA from Scratch for DNA-based Data Storage

SDDEC23-05

*Anna Hackbarth, Caden Wortman, Astha
Upadhyay, Evan Walters, Colin Frank,
Rachel San Agustin*

Introduction

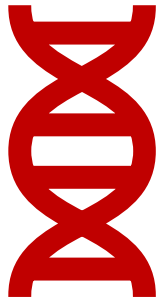
Problem Statement:

- DNA sequencing is well-developed, but DNA synthesis is expensive and difficult to access in small quantities.
- This project has a wide range of potential applications in fields such as data storage, biotechnology, medicine, and genomics.

Solution:

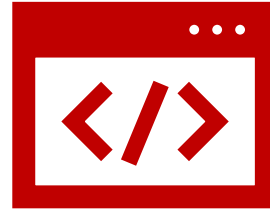
- To facilitate small scale synthesis, we will use custom built software in tandem with integrated hardware and a modular flow device to create DNA fabrication technology.
- This will be used to make DNA strands for testing and research purposes.

Functionality and Requirements



Functionality:

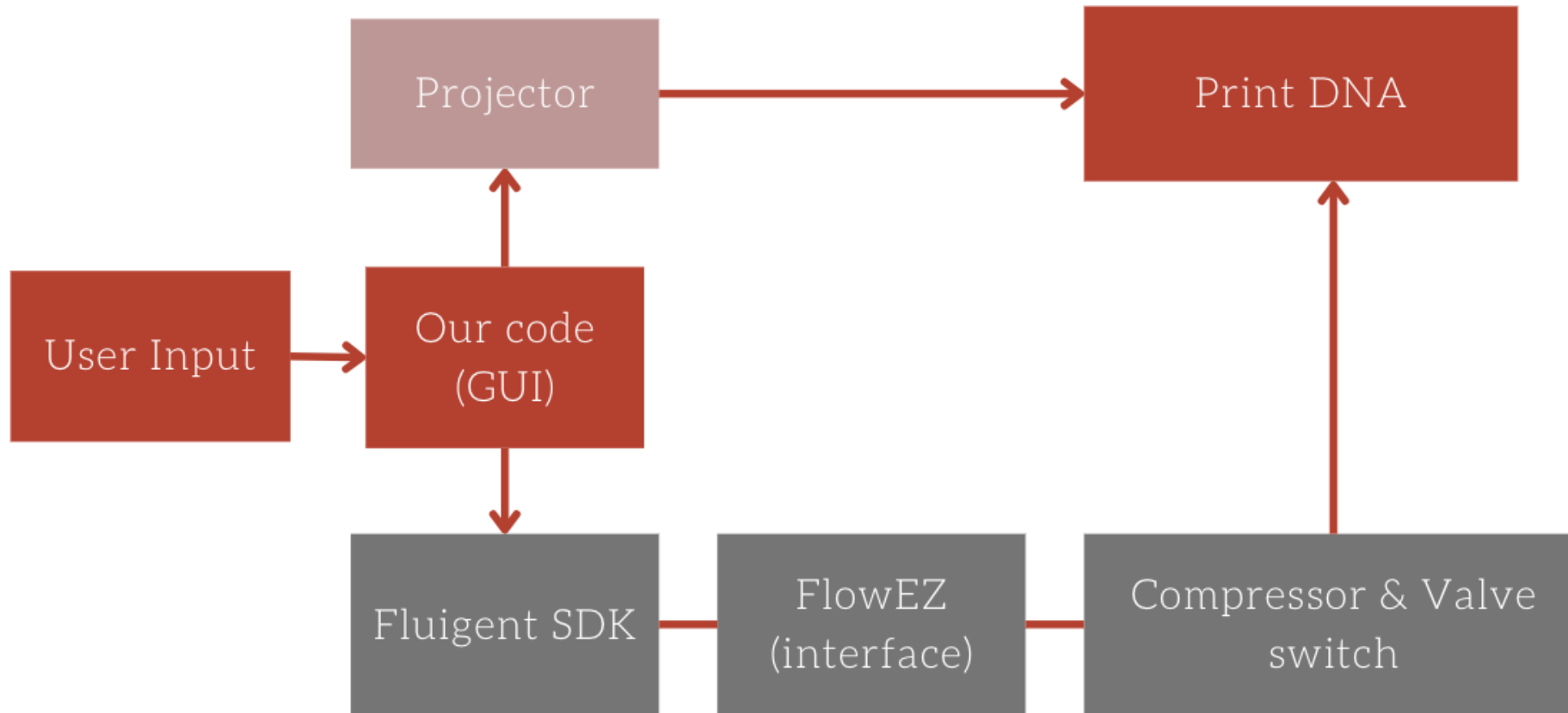
To combine fluid flow control, UV light projection, and software to create DNA strands from nucleotide solutions



System needed to be:

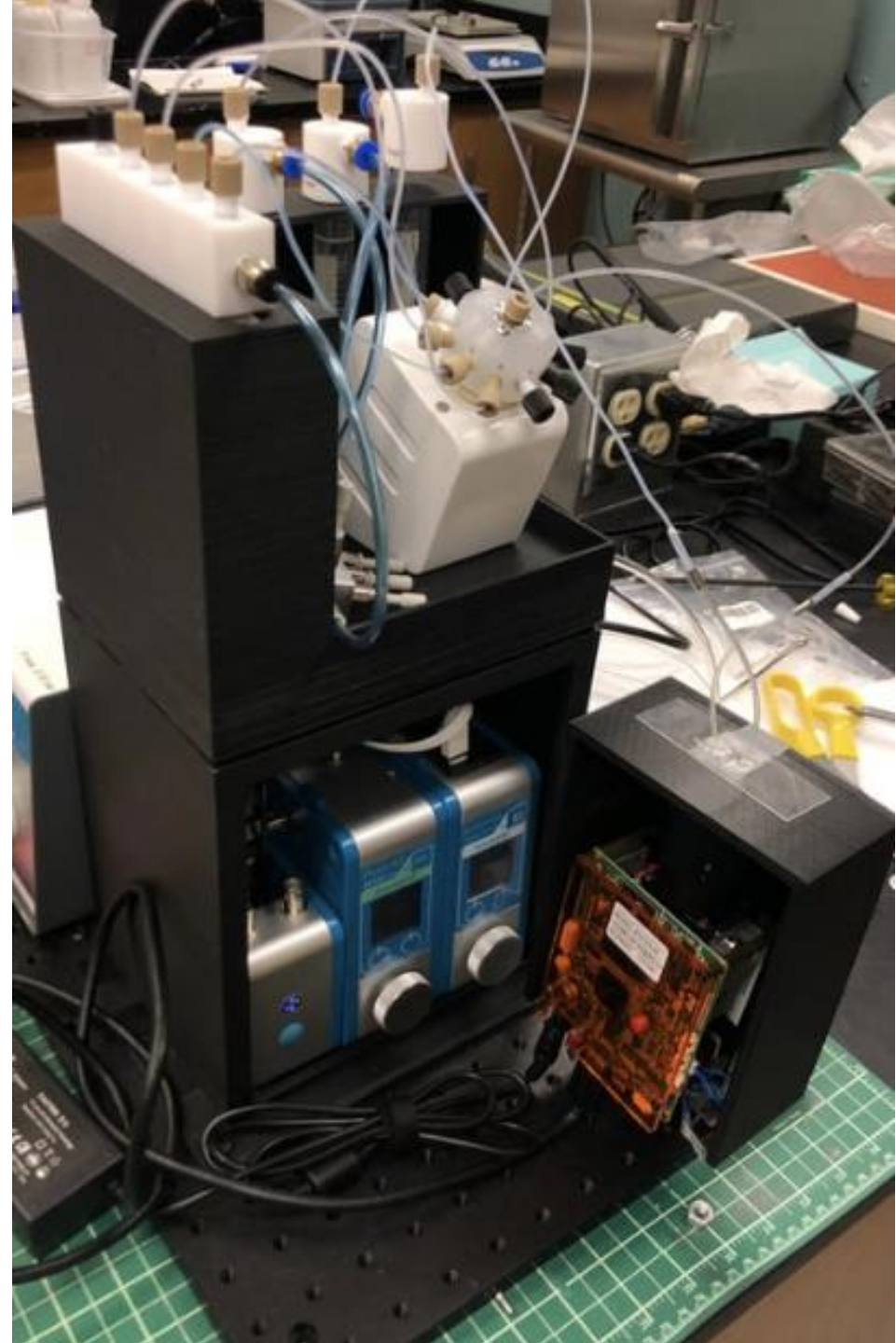
User-friendly
Modular
Accessible
Easy to maintain

Whole System Breakdown

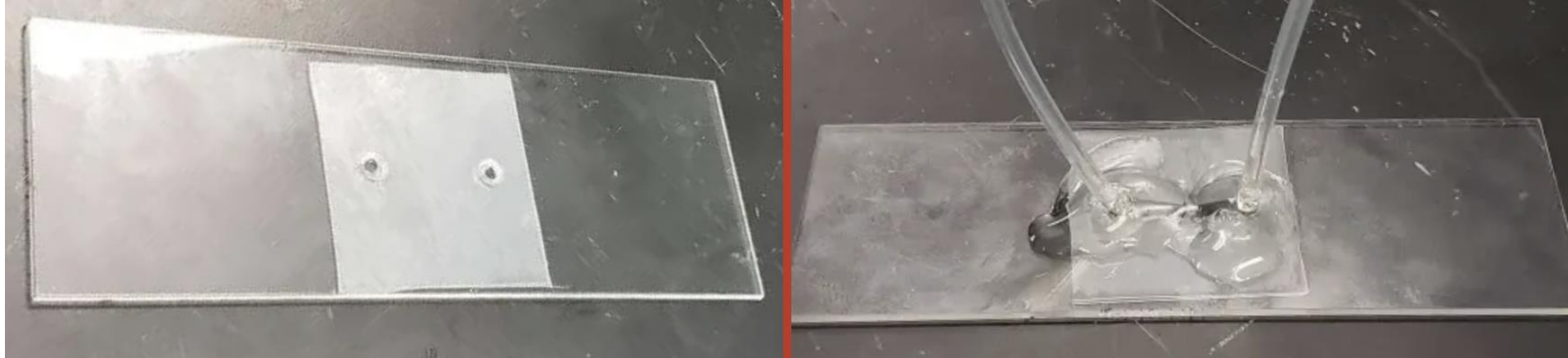


Fluid Flow System

- Software Development Kit (SDK) in C# provided by Fluigent
- Pressure adjustment, sensor reading
- Nucleotide solutions, switcher, interfaces
- Housing for fluid flow system



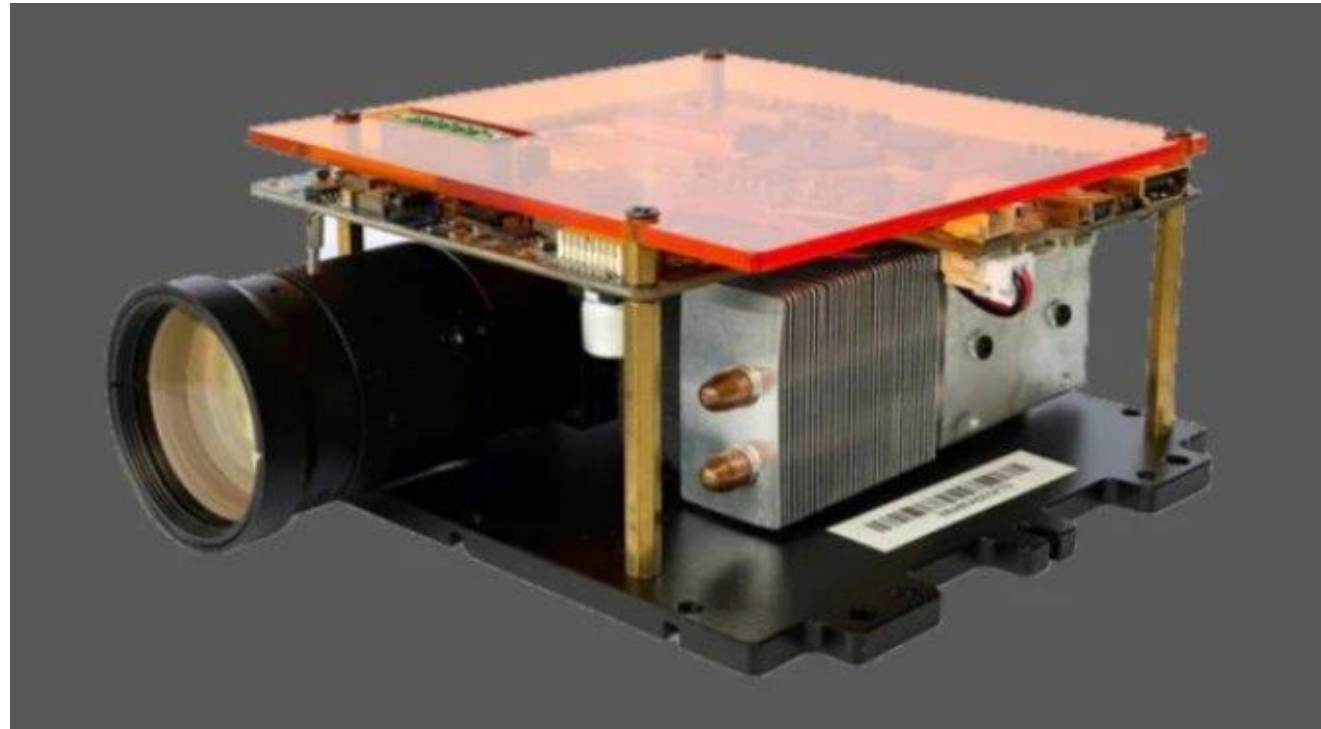
Flow Cell Construction



- Glass slide with tubing ports, channel cut between ports
 - This is where DNA strand is built and cured by the UV light

Projector

- Ultra-Violet Projector from SICUBE
- HDMI connection
- Added 5 mm Lens Extension



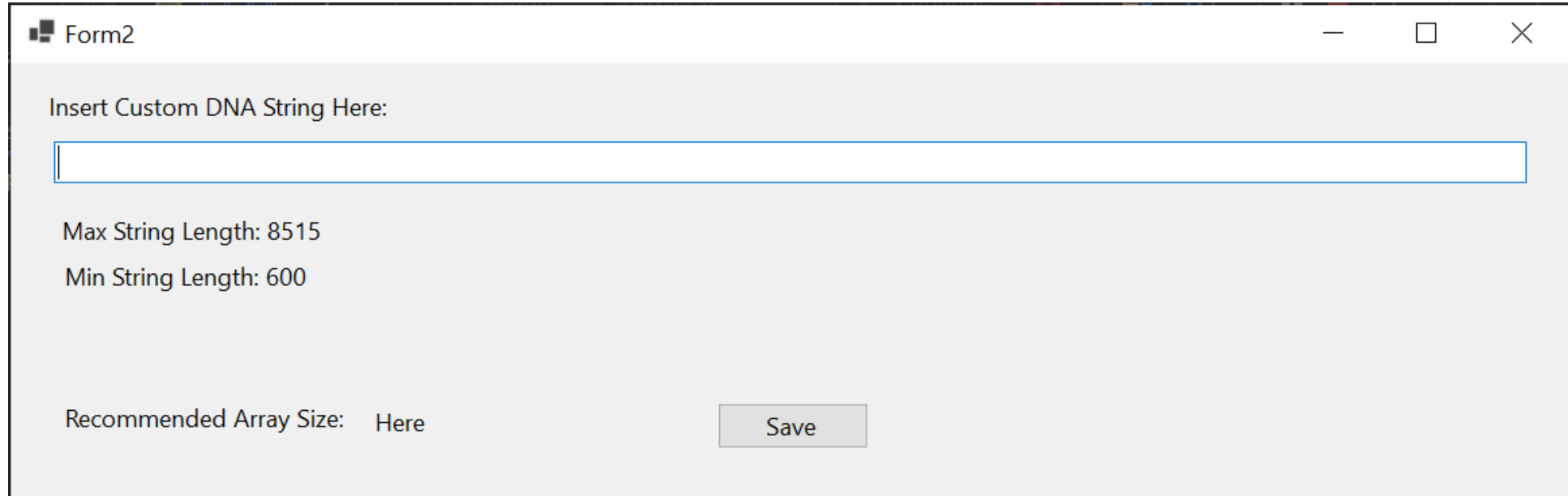
Graphical User Interface (GUI) - Form 1

- User inputs allow customization of DNA printing process
- Check/Save button saves information in global variables

The screenshot shows a Windows-style window titled "Form1" with standard minimize, maximize, and close buttons. The interface contains the following elements:

- A button labeled "Click to Enter DNA String" at the top left.
- Input fields for "Space Between Cells (nm)", "Array Size" (with "Height" and "Width" dropdown menus), and "Exposure Time (ms)".
- Checkboxes labeled "Space Check:", "Array Size Check:", and "Exposure Time Check:" with corresponding text "Space Here", "Array Size Here", and "Time Here".
- Input fields for "Set Pressure for Nucleotide (mBar)" and "Pressure Duration for Nucleotide (ms)".
- Checkboxes labeled "Pressure Check:" and "Duration Check:" with corresponding text "Pressure Here" and "Duration Here".
- Input fields for "Set Pressure for Wash (mBar)" and "Pressure Duration for Wash (ms)".
- Checkboxes labeled "Pressure Check:" and "Duration Check:" with corresponding text "Pressure Here" and "Duration Here".
- A "Check/Save" button at the bottom right.
- A "Start" button at the bottom center.

GUI – Form 2

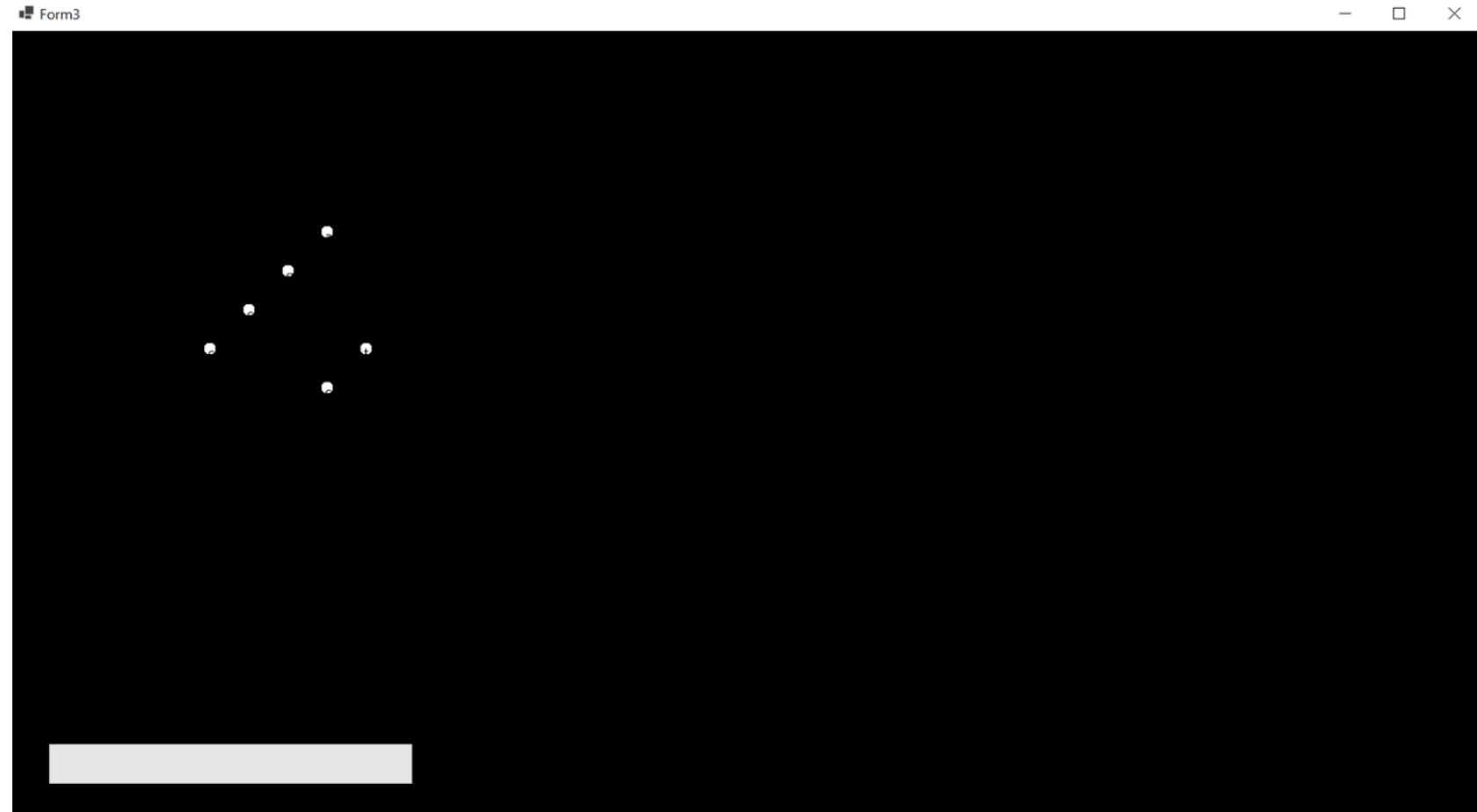


The screenshot shows a window titled "Form2" with a light gray background. At the top left, there is a small icon and the text "Form2". At the top right, there are standard window control buttons: a minus sign, a square, and an "X". Below the title bar, the text "Insert Custom DNA String Here:" is displayed. Underneath this text is a long, empty text input field with a blue border. Below the input field, the text "Max String Length: 8515" and "Min String Length: 600" is shown. At the bottom left, the text "Recommended Array Size: Here" is displayed. At the bottom center, there is a gray button with the text "Save".

- When "Click to Enter DNA String" is clicked this form will open
- Paste the DNA string and it will get stored in a global variable

GUI – Form 3

- Start button is in the top left and disappears when printing process starts
- Progress bar located bottom left
- White dots are projected onto the flow cell to cure nucleotides



Technical Challenges & Design Changes

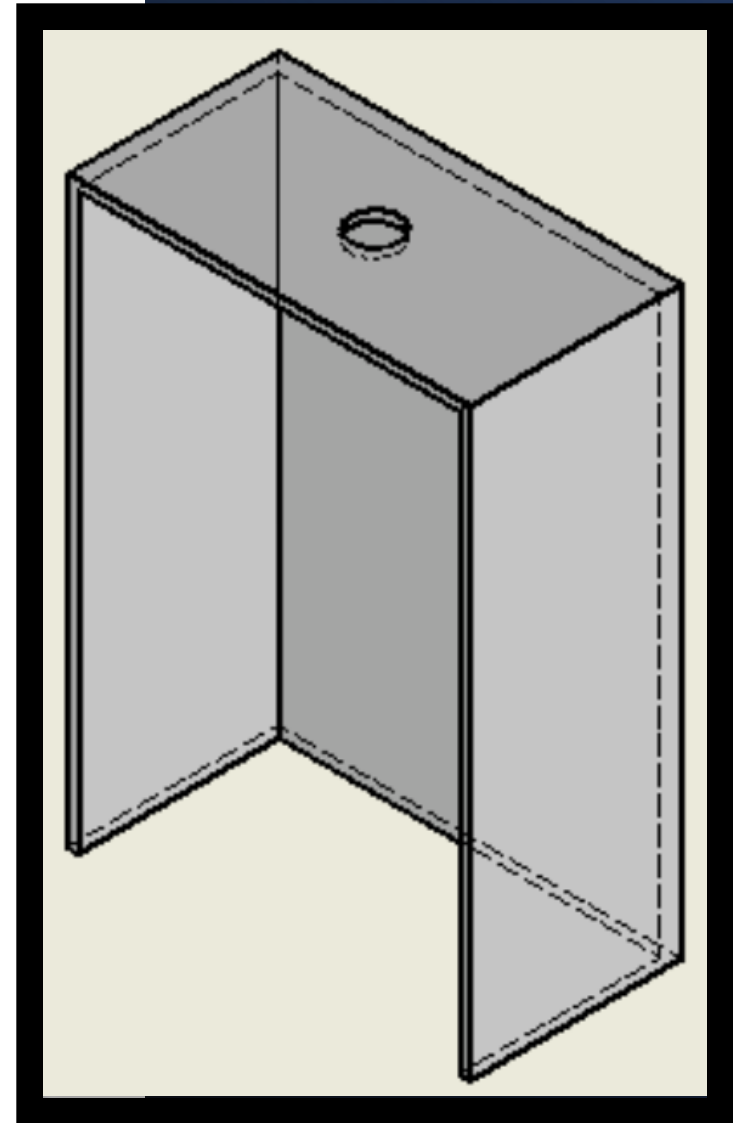


Fluid Flow System

- Made use of OxyGen Software to control the flow cell
- Used SDK and altered the code according to the project's requirements
- Tried to get the code running on multiple different applications and finally settled on Visual Studio
- Worked on connecting the flow system to the GUI

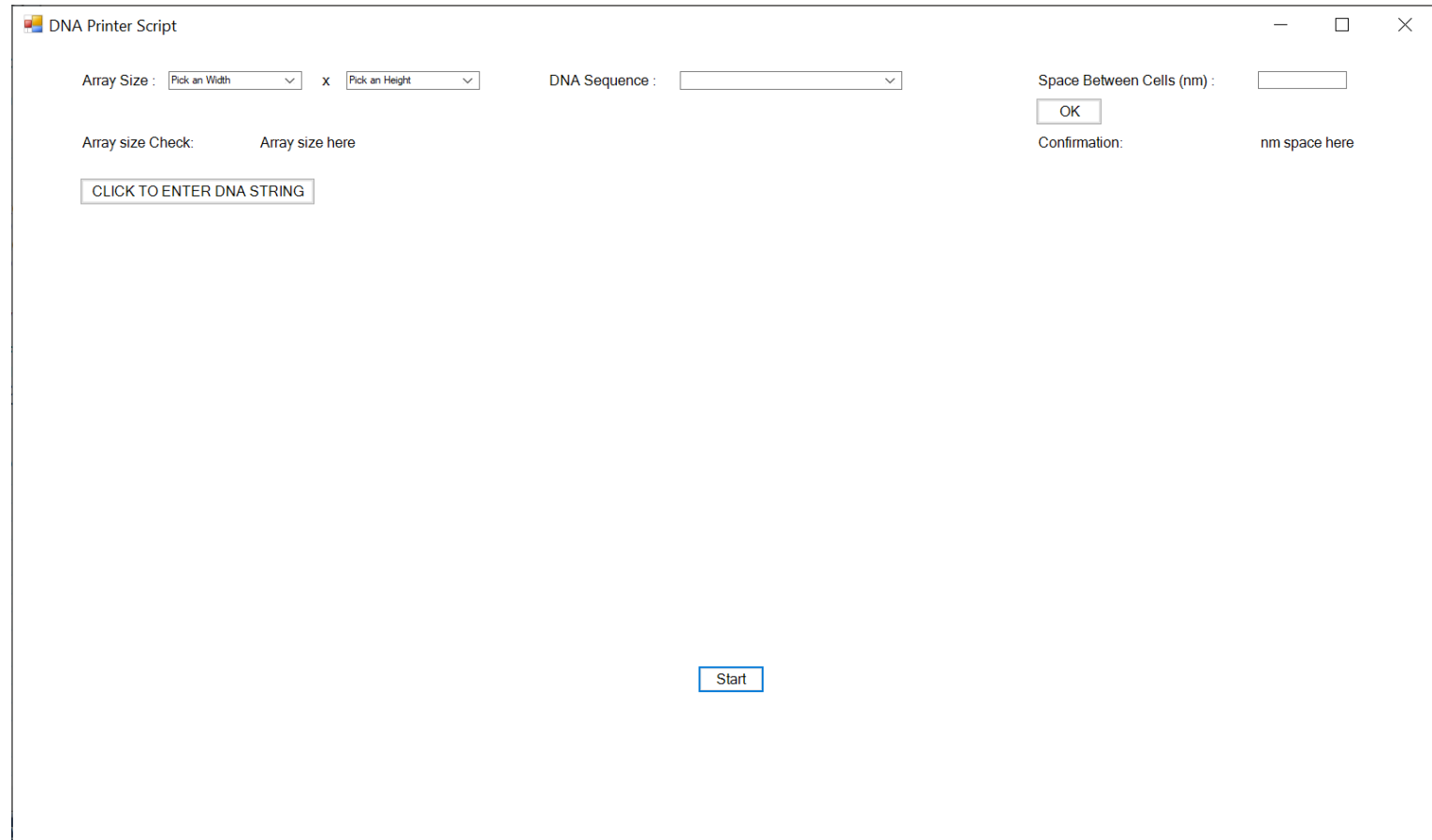
Projector

- Initially used a TI projector with replacing the blue internal LED with a UV LED
 - Overheating issues
- Replaced with the current Ultra-Violet Projector from SICUBE
 - Went through resolution testing using Photolithography
- Still needing higher resolution, added a 5mm lens extender to allow for smaller imaging
- New housing designed to use with projector



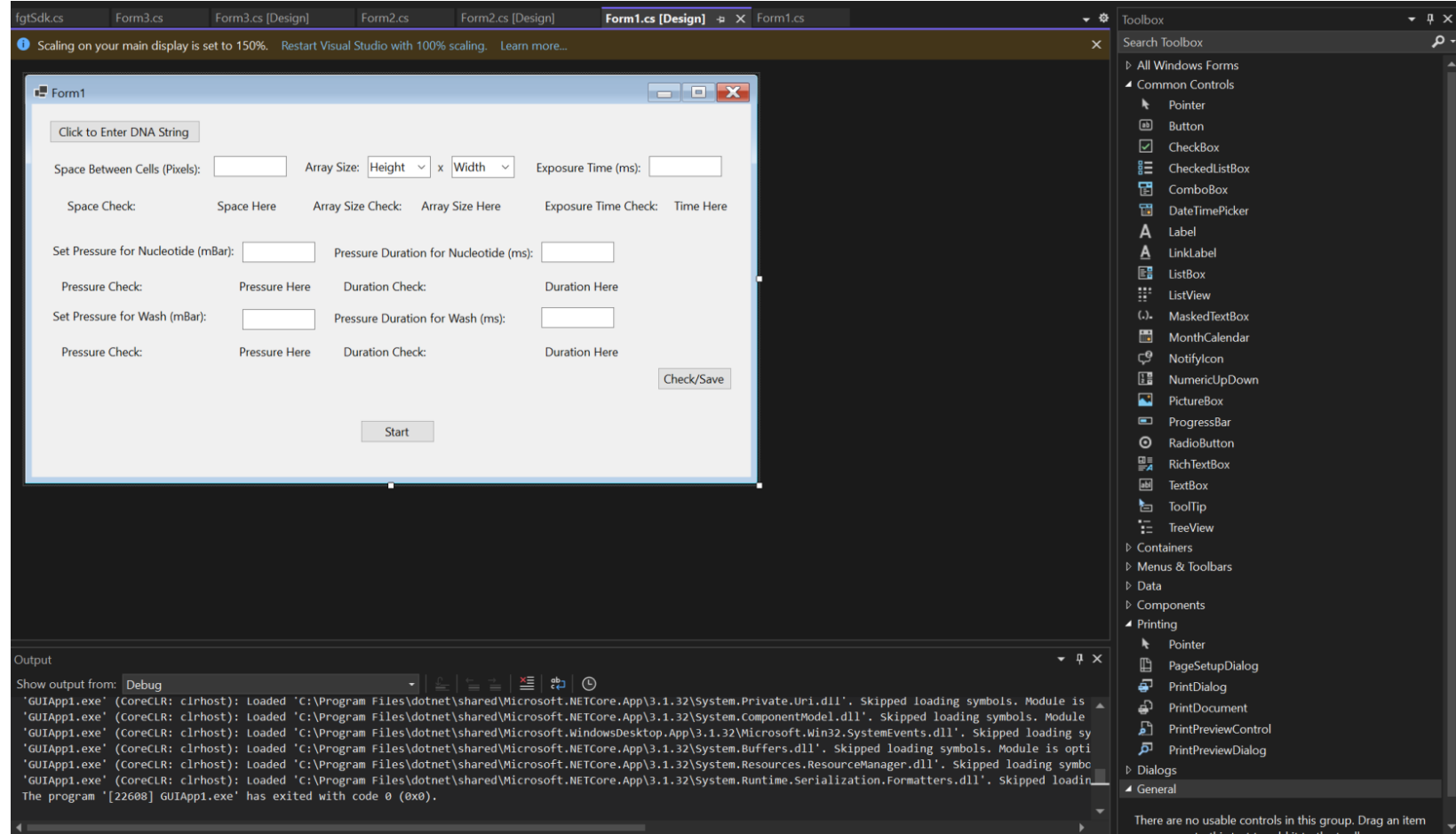
GUI 1.0

- Started in Powershell ISE to create a customizable windows form
- Didn't have functionality to communicate to Fluid Flow SDK
- Needed to move to Visual Studio



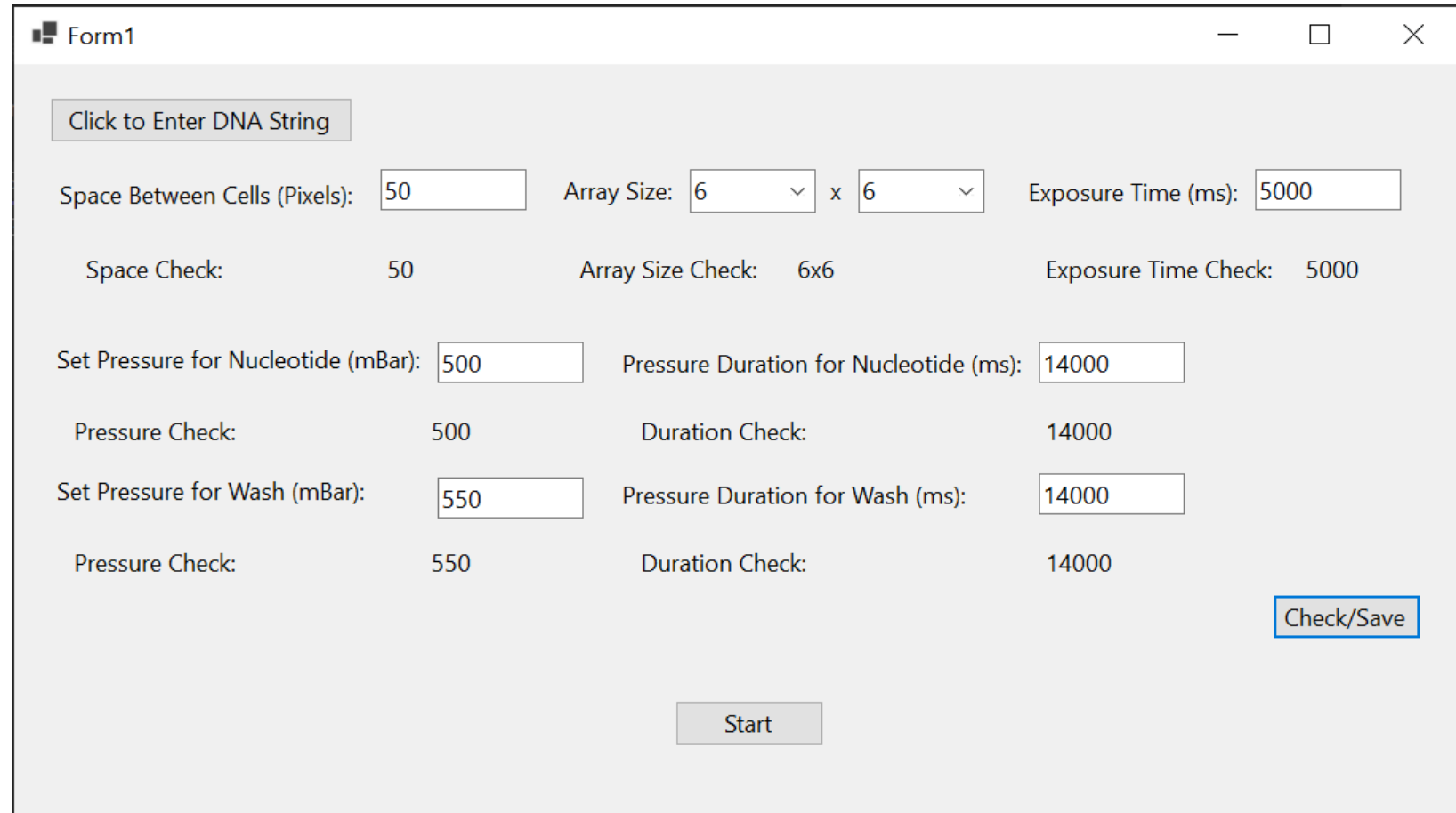
GUI 2.0

- Used Visual Studio design functionality
- Converted main logic
- Used .NET Framework 4.7 Windows Application



GUI 3.0 (Current Version)

- Fluid Flow System SDK uses .NET CORE 3.1
- .NET Framework 4.7 not compatible with .NET CORE 3.1
- Changed from a timer to "Task.Delay()" to avoid threading issues



The screenshot shows a Windows application window titled "Form1". The interface includes the following elements:

- A button labeled "Click to Enter DNA String".
- Input fields for "Space Between Cells (Pixels)" (50), "Array Size" (6 x 6), and "Exposure Time (ms)" (5000).
- Check values for "Space Check" (50), "Array Size Check" (6x6), and "Exposure Time Check" (5000).
- Input fields for "Set Pressure for Nucleotide (mBar)" (500) and "Pressure Duration for Nucleotide (ms)" (14000).
- Check values for "Pressure Check" (500) and "Duration Check" (14000).
- Input fields for "Set Pressure for Wash (mBar)" (550) and "Pressure Duration for Wash (ms)" (14000).
- Check values for "Pressure Check" (550) and "Duration Check" (14000).
- A "Check/Save" button in the bottom right corner.
- A "Start" button at the bottom center.

Demonstration Video

Video Link:

[Senior Design Demo.mov](#)

Thank You

- Professor Meng Lu
 - Client, Advisor, Mentor, and Resource
- Professor Rachel Shannon
 - EE 491 Professor
- Professor Thomas Daniels
 - EE 492 Professor
- Shirin Parvin
 - Graduate Student, Flow Cell Construction Aid
- Qinming Zhang
 - Graduate Student, Projector Testing Aid
- Leland Harker and ETG Staff

Questions?

