Computer Science & Computer Engineering

TileScad

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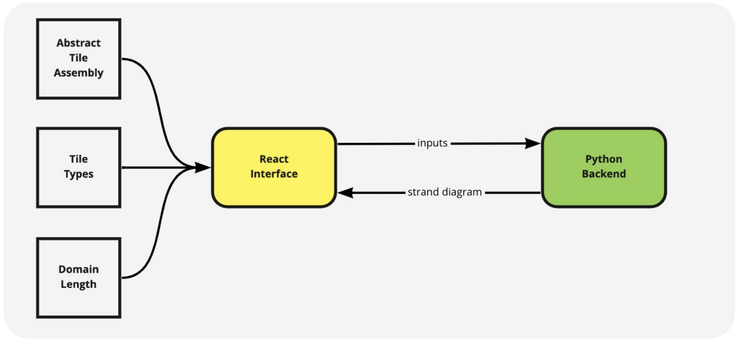
Introduction*

The design of DNA strands is an expensive and time-consuming process. Researchers in the nanotechnology field waste valuable resources transforming nanostructure designs into DNA strands. The goal of the project is to simplify the process of constructing DNA strand designs by creating a quick and easy way for researchers to convert nanostructure tile designs into DNA strand diagrams. Instead of having to use multiple independent software packages, our project will allow researchers to easily design an abstract nanostructure tile assembly and transform it into a DNA strand diagram, readable by Scadnano. Scadnano is web-based software for visualizing DNA molecules as strand diagrams. This project focuses on a DNA nanostructure fabrication process called *DNA tile assembly*. In tile assembly, DNA strands are conceptually organized into rectangular structures called *tiles* which are the fundamental building unit in tile assembly structures. Multiple types of tiles can be designed so that when mixed in a solution, tiles attach to each other in a way that builds the intended DNA nanostructure.

Requirements*

The fundamental requirements include the ability to design a DNA tile assembly on an arbitrarily designed canvas. Each tile must also be customizable. After the design, the user must receive a DNA strand diagram that can be downloaded for future use in Scadnano. All of these components must be hosted on a web server for easy access and transition to Scadnano. Another requirement includes a clear and understandable user interface and user experience.



Design*

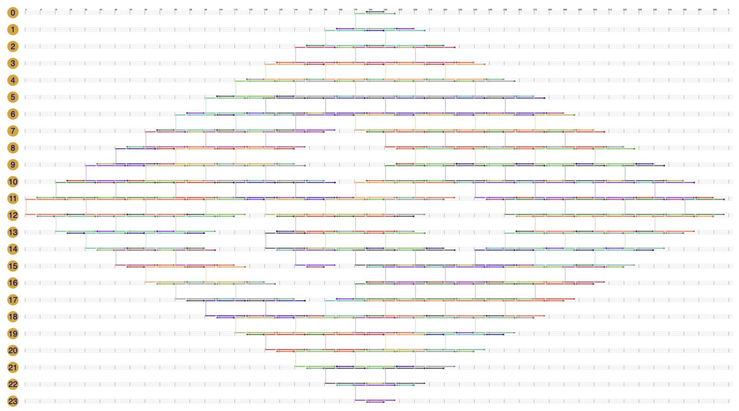
The architecture consists of two primary components: the user interface written in React and the backend server written in Python. Communication between the user interface and the backend is facilitated by an API service written in JavaScript.

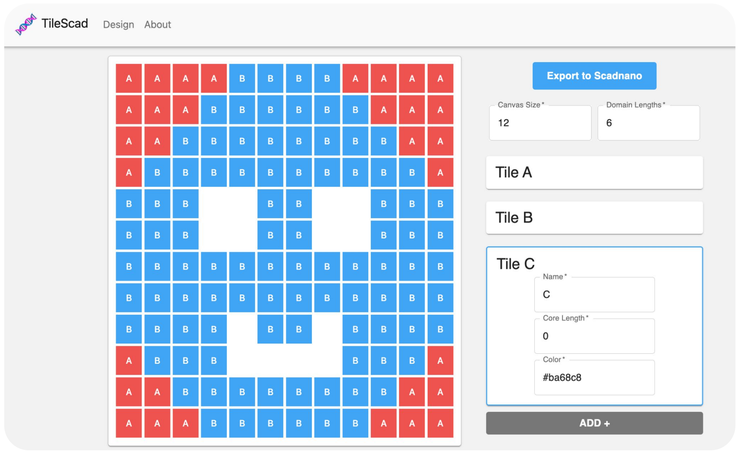
Front-End

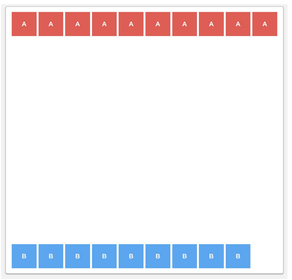
The front end is responsible for providing users the ability to design and export abstract nanostructure tile assemblies. Through the interface, the user can define the canvas size and the binding domain lengths for the tile design, as well as define different tiles that can be added to the design. With this design, the user is able to select the tiles they have defined and place them into the canvas where they see fit. The front end validates the tile design before it is uploaded to the API. The user interface is built using React 16.4.0 and has two main components: the Tile Assembly Canvas and the Tile Menu. The front end uses React Material UI 5.5.0 to customize the look and feel of the interface.

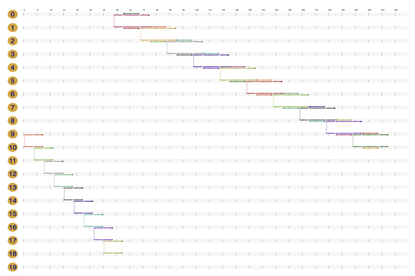
Back-End

The main logic of our server is written in Python 3.10.0. When the user uploads the input files, the backend will be responsible for receiving the files, processing them into the resulting strand diagram, and sending the processed file back to the user. Before the user's uploaded data is processed into a Scadnano file, the data is first verified to ensure that it is valid.









Results*

The resulting project TileScad simplifies the DNA nanostructure design process. TileScad provides users to be ability to design abstract nanostructure tile assemblies by defining the canvas size, domain lengths, and tiles. Once the user is satisfied with the design, they can then convert the design created into a JSON file readable by Scadnano. This greatly expedites the process of synthetically designing DNA strands. With the use of our software, scientists will save a great amount of time and resources that could have been lost otherwise.

Future Work*

There are potential aspects of software associated with DNA nanotechnology that can be improved upon. One of the biggest obstacles, which our software overcame, is the fact that there are multiple platforms and packages. We could expand and make TileScad more robust and comprehensive.