Laboratory of Natural Information Processing
DA-IICT Gandhinagar

DNA Pen

User Manual

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Credits & Team

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General Information

1. Introduction

DNA is a fundamental unit of any organism, which makes it the most intriguing and exciting option available for construction of nanostructure. Due to its specificity of the base pairing, it weaves itself in to the target structures at nano level. DNA origami [1] is a simple method used to construct complex two-dimensional (2D) and three-dimensional (3D) structures by DNA self-assembly [2]. However, conducting random experiments for constructing such structures is exhaustive and expensive, hence, there is need to develop the software for such nanoscale construction. DNA Pen is one such tool for creation of two dimensional DNA nanostructures which employs the idea of DNA Bricks [3] [4]. Desired shapes are created on the molecular canvas and the respective sequences required for the building of the shapes is generated as output. It generates error free DNA sequence with the error correction and stability modules [5]. By the designing of the structures, visualizing the structure, the software increase the efficiency and productivity of the nano scale construction

2. Overview

DNA Pen has been primarily developed to facilitate the construction of nanostructures by DNA Brick. The software encourages the users to first visualize the structures, draw them accordingly on a virtual sheet and then generates the required DNA strand sequence. By this we not only achieve automation but also minimize the need for repetitive experimentation for developing one structure. The reduction in exhaustion is because of two processes that the software undertakes. The software is able to give infinite number of DNA strand sequences for the same shape. It allows user to choose to variety of DNA strands for the experiments.

3. Product Scope

This software provides the user with:

- Visualization and list of DNA strand sequences for DNA Bricks of different dimensions.
- Visualization and list of DNA Brick sequences for 2D structures drawn on a free-hand draw grid.
- Visualization and list of DNA strand sequences for 2D structures drawn on a digital grid. (Each cell in the grid represents one tile of DNA Brick)
- DNA Pen checks for the thermal stability of the DNA strand sequences generated. Also it makes sure that there are no possibilities for any kind of secondary structures being formed. The strings then go through a refined process to ensure that they satisfy the constraints for error-correcting codes.

4. Product Perspective

This product's main aim is to make the process of making the computerization and computation of DNA Origami structure user friendly.

System Summary

Operating Systems – Windows 7, Mac OS X

This software requires the system to have specifications similar to: - 2.4 GHz Core 2 Duo, 100 MB Hard Disk, 2GB Random Access Memory and Basic peripherals like keyboard, mouse etc.

Getting Started

Once you have successfully installed the software, open DNA pen by double clicking on the icon available on your desktop screen, a window with four menu options on the menu bar will appear. The dialogue box generating the random tips will appear that will guide the user about the software utility. It includes the button for creating the new project. User can click on this button or can select the option "**Create a new project**" from the file menu. This will open the dialogue box that will ask to enter the name of the project. Once user specifies the name, select the path to save the project at specific location and click on "create" button. Once you save the project folder at specified location, this folder consists of all the output files of your project. The main features that the software provides the user with and which are spanned across these four options on the menu bar are:-

- Work on Free-hand Molecular Canvas
- Work on Digitized Molecular Canvas
- Save Detailed DNA Data
- Save DNA Sequence
- Save PDF
- Create Latex file
- View Draw Image
- Edit Dimension
- Estimator
- Capture Canvas Screenshot
- Clear
- Social Media

1. Free Hand Molecular Canvas

This option is available under the tools menu of the menu bar. When the user clicks on **"Tools -> Free Hand Molecular Canvas"**, the display area on the DNA Pen's home window where user can draw the 2D structure he wants to create. Using this molecular canvas is very easy; a simple mechanism is to be followed. The user has to click and drag the mouse simultaneously on the canvas in accordance with the shape that he wants to create. It works just like drawing tool Paint, where you can draw any shape. If you want erase some you can select **Erase** button on right hand top corner of the screen. To again start drawing select Pen mode by **Pen** button next to erase button. Figure 1 is the example of the hindi letter "OM" created on the free hand molecular canvas. User can draw any free hand shape he wishes to built at nano scale on this free hand molecular canvas.

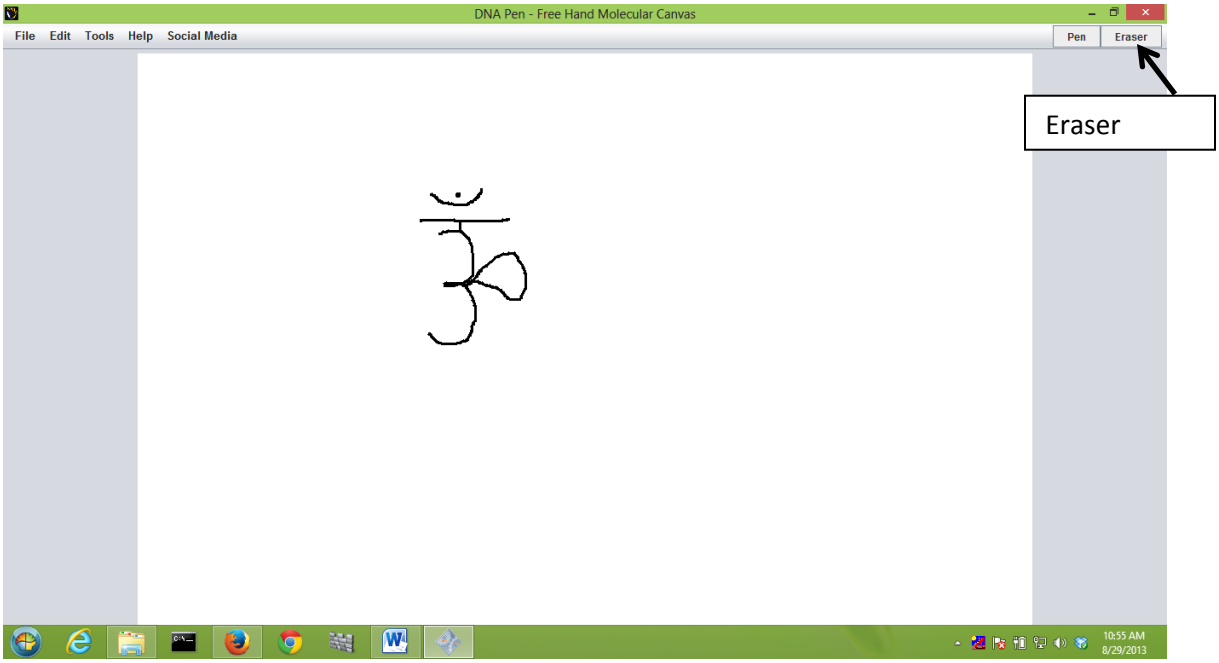


Figure 1 Free Hand Molecular Canvas

2. Digitized Molecular Canvas

This option is available under the tools menu of the menu bar. When the user clicks on the **"Tools-> Digitized Molecular Canvas"**, the display area on the DNA Pen's home window would be filled up with a gridded canvas. Here the canvas would be filled with cells which are bigger in size as compared to the cells available in Free Hand Molecular Canvas. The user simply needs to click on the cell that he wants to be a part of his structure. The cell gets highlighted as the user clicks on it. Figure 2 is the example of the nano shape of Cross designed on the

digitized canvas. There is an undo option available in the tools which enable the user to undo the designed once built. Also by clicking twice on the cell it will de-highlight the cell.

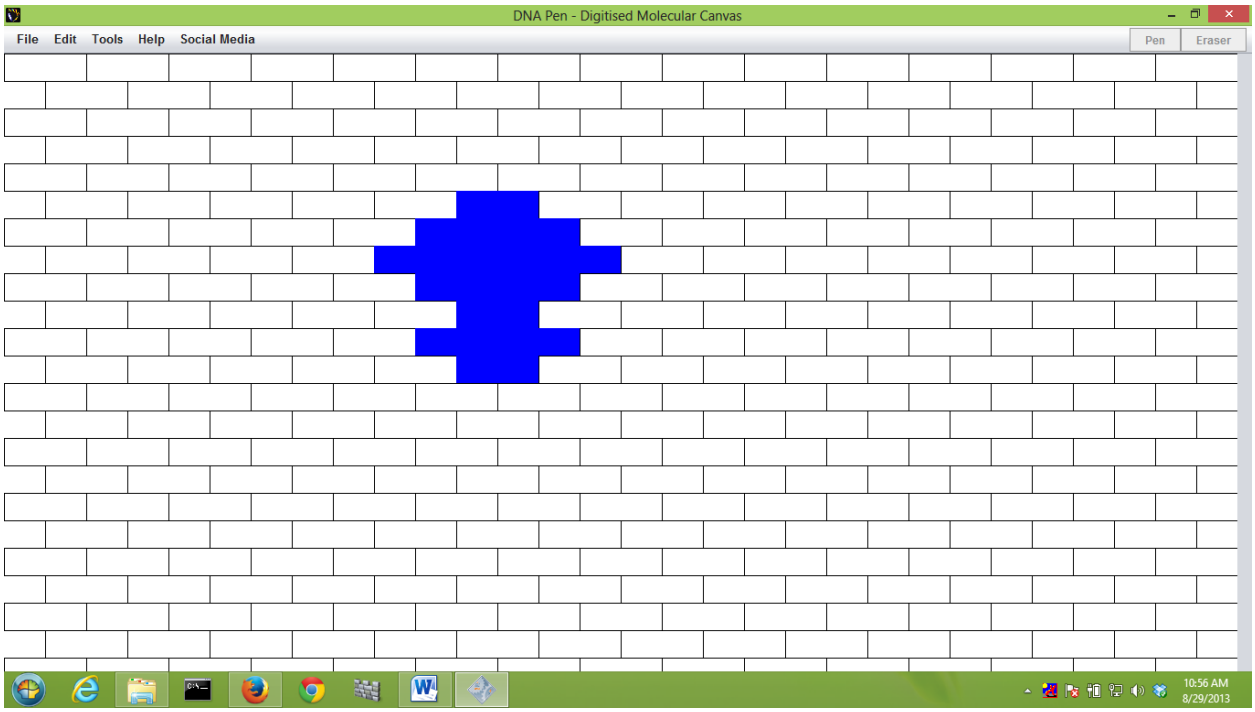


Figure 2: Digitized Molecular Canvas

3. Save Detailed DNA Data

This option is available under the File menu of the menu bar. When the user clicks on **"File -> Save Detailed DNA Data"**, DNA Pen checks whether the user has created a design on either of the two molecular canvases available. The software saves an excel file which contains an ordered list of the DNA strand sequences required to make such a structure experimentally and coordinates of the tile used to generate the shape. A pop-up window is generated that confirms that file is saved successfully at specified location with the name DNAData_filename. Figure 3 shows the way to save the designed shape, which will generate the sequence to for the designed shape.

4. Save DNA Sequence

This option is available under the File menu of the menu bar. When the user clicks on **"File -> Save DNA Sequence"**, DNA Pen checks whether the user has created a new Brick and changed the dimensions from the default values. The software saves an excel file which contains an ordered list of the DNA strand sequences used to make the Brick. A pop-up window is generated that confirms that file is saved successfully at specified location with the name DNAData_filename.

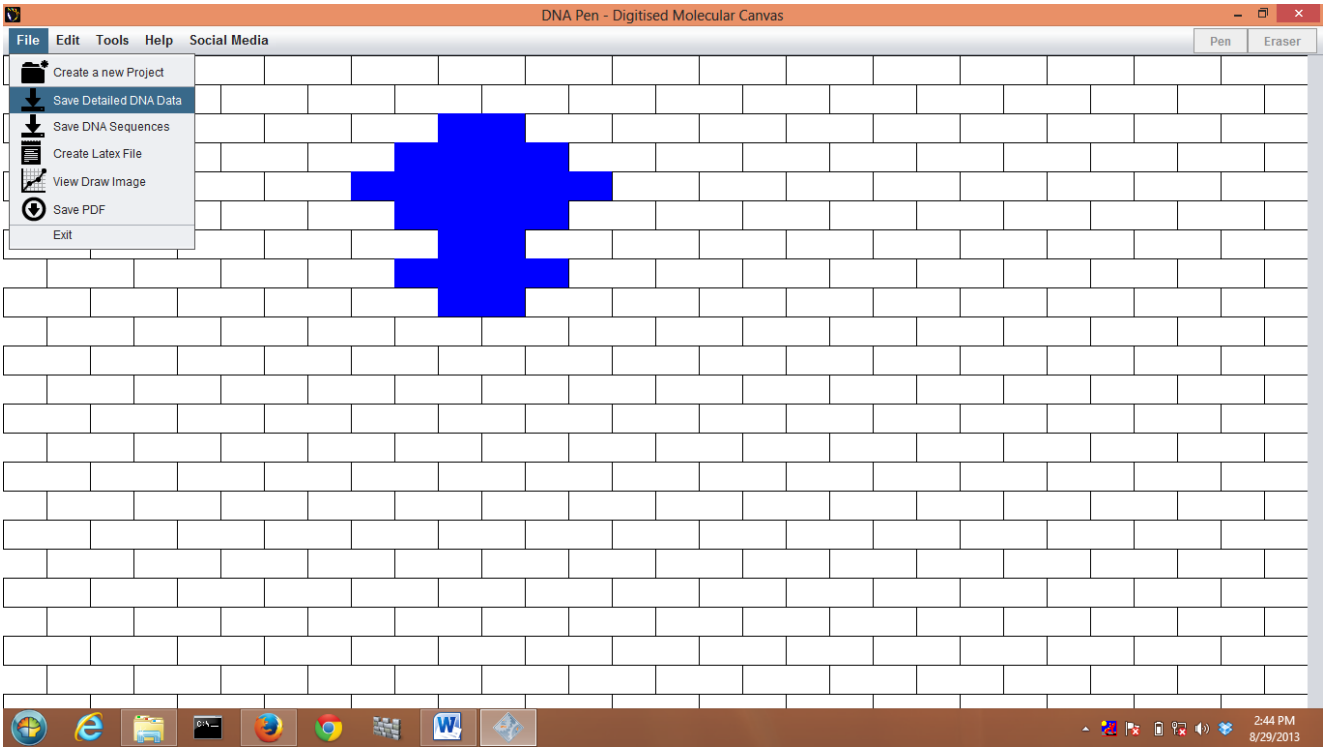


Figure 3: Save detailed DNA option generate DNA sequences

5. Save PDF

This option includes all the output in one PDF. Once you draw the shape on the canvas, click on this option. It will include the barcode number which is unique to all the shapes drawn by the user. This will help to identify the shapes drawn by him uniquely. It will include image of the structure designed in the canvas, dimension of the brick and brick image. This all are the output in one page which will help user to understand it better. A pop-up window is generated that confirms that file is saved successfully at specified location with the name FreeGridData_filename (If user had drawn on freehand molecular canvas) and DigitizedGridData_filename.

6. Create Latex File

This option includes all the latex file of the DNA sequence and its related information like total number of half tile and full tiles and total DNA sequences generated.in one PDF. Once you save the DNA sequences, click on this option. This will create the latex folder which include image of the shape and PDF that includes all the DNA sequences in well-organized tabular format. All are the output in one folder which will help user to understand it better.

7. View Draw Image

This option will generate the image of the shape drawn. It will display the tiles arranged in specific manner according to the shape drawn on the molecular canvas. This will allow the

user to understand how the specific shape gets arranged according the design of the single stranded tiles. Figure 4 displays the arrangement of the SST for the shape in figure 3.

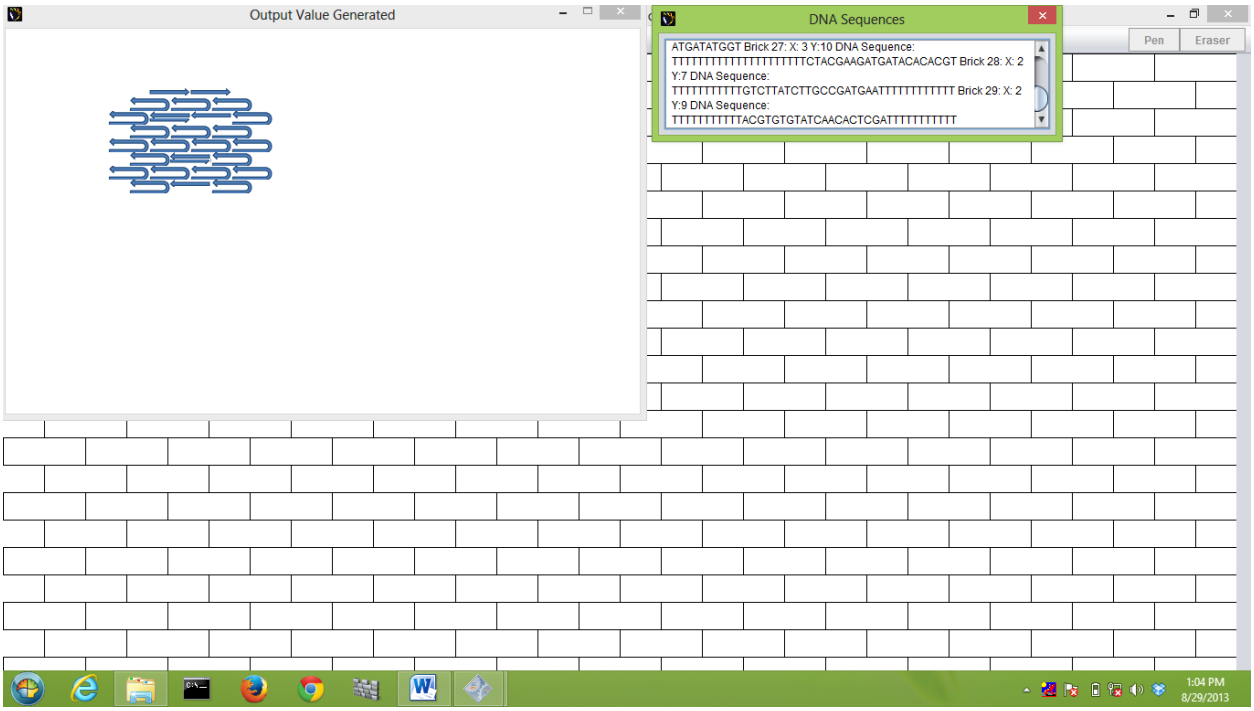


Figure 4 SST arrange in specific manner by view draw image option

8. Edit Dimensions

This option is available on the menu bar under the Edit menu. When the user clicks on **"Edit -> Edit Dimensions"** a small pop up window opens up where the user can select any dimensions from dropdown options. The pop-up has 2 buttons at the bottom of the window, the **"Save"** and the **"Cancel"** button. The Save button saves the dimensions of the brick created and now if the user works on the molecular canvas, the bricks used in the backend would be of the dimensions as specified by the user. Figure 5 shows the dialouge box appear when user wish to change the brick dimension.

9. Estimator

This option is available on the menu bar under the Tools menu. When the user clicks on **"Tools-> Estimator"** a small pop up window opens up where the user can enter the cost per base of DNA. This will give you total cost of the DNA sequences used to generate DNA sequences in US dollar (USD).

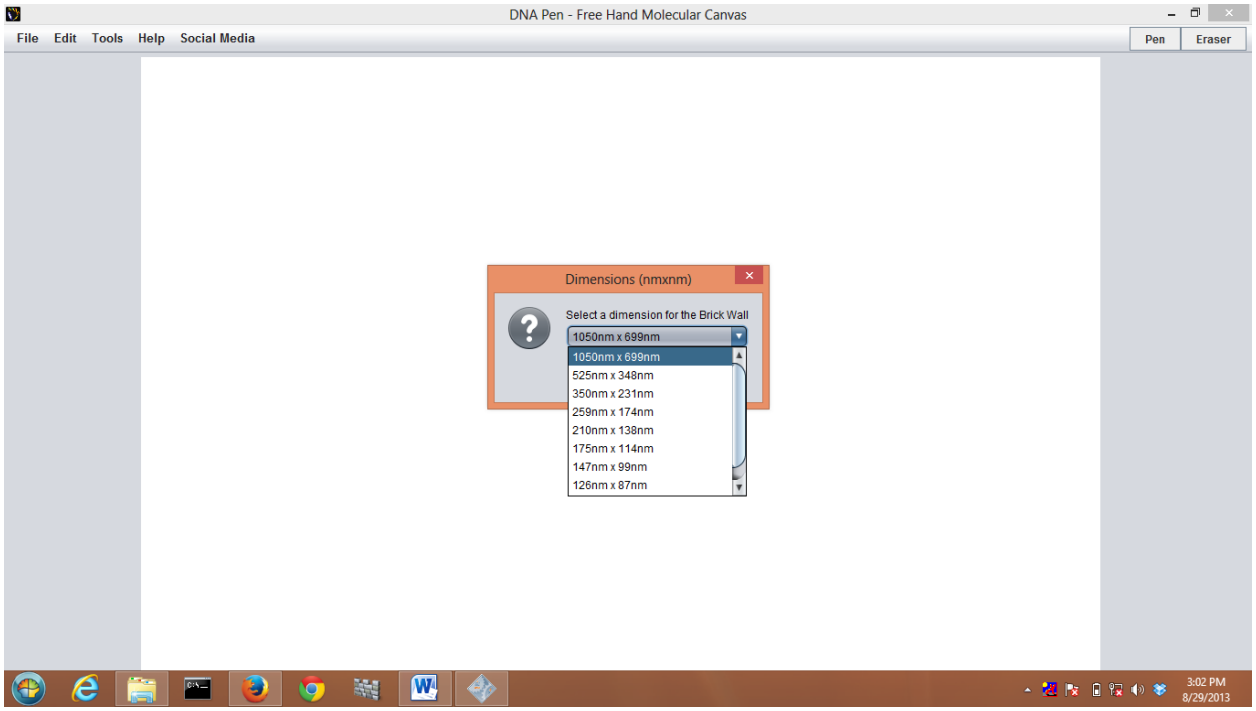


Figure 5 Dimensions for the free grid molecular canvas.

10. Capture the screenshot

This will take the screenshot of the canvas. It is available in Tools menu. This will ask user to save the screenshot at user choice destination.

11. Clear

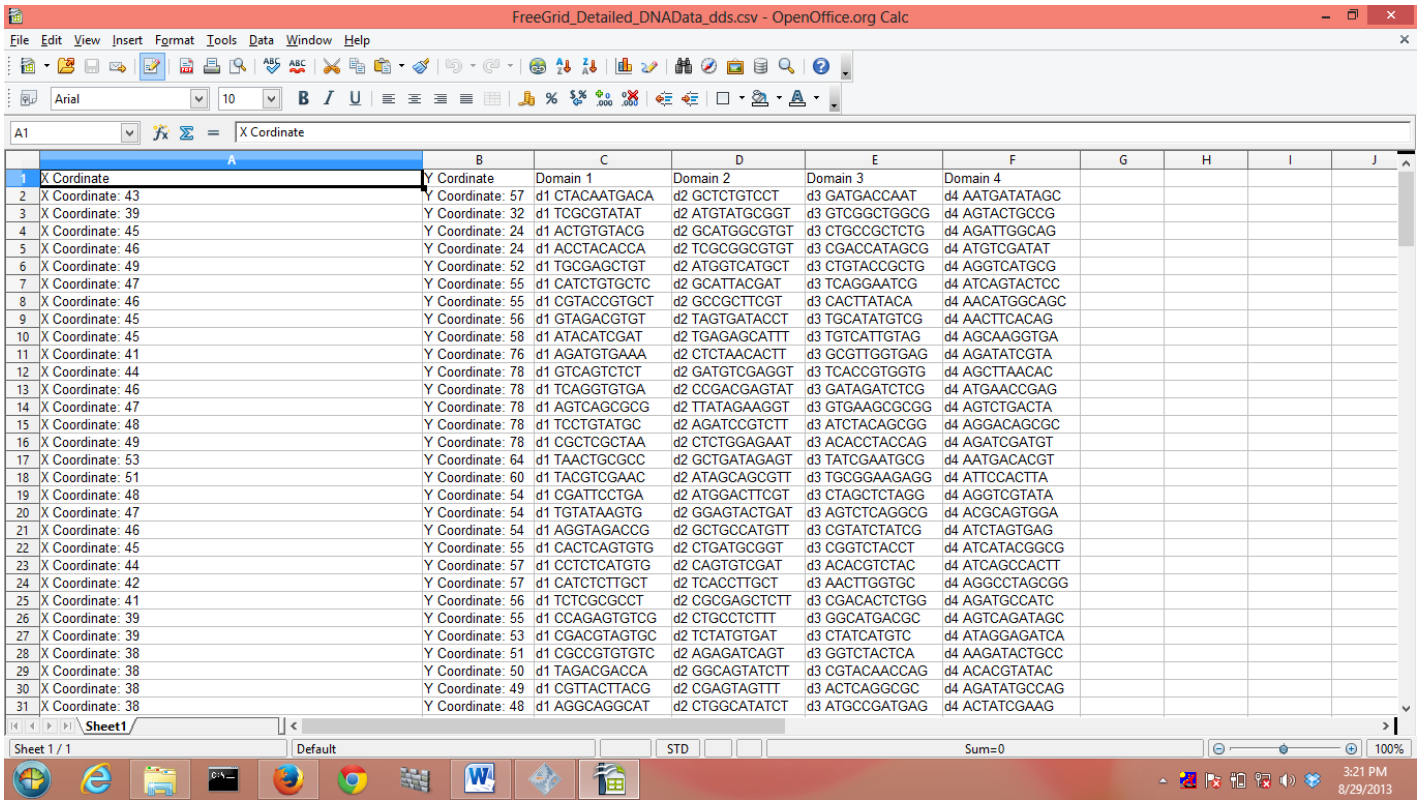
This will clear your shapes drawn on the molecular canvas.

12. Social Media

This provides links to follow us on the social media websites. You can follow DNA Pen at Facebook, Twitter, Quora and You tube.

Output

Once you save the draw data, the output generated is in the excel format. The destination place which you have selected to save the draw data, contains the excel file. Double click on the file to open it. It gives the information about the base sequences required for the shape designed. Also it includes the sequences for each domain in the DNA bricks, number of full and half tile for each domain and number of stick ends. It generates the coordinates for each base in the sequence on the basis of shape constructed on the molecular canvas. Figure 6 show the sample output file for the above shape mentioned in the digitized molecular canvas. This output helps the researcher to design the shape with respect to arrangement of bricks DNA and the stick ends.



	A	B	C	D	E	F	G	H	I	J
1	X Cordinate	Y Cordinate	Domain 1	Domain 2	Domain 3	Domain 4				
2	X Coordinate: 43	Y Coordinate: 57	d1 CTACAATGACA	d2 GCTCTGTCCT	d3 GATGACCAAT	d4 AATGATATAGC				
3	X Coordinate: 39	Y Coordinate: 32	d1 TCGCGTATAT	d2 ATGTATGCGGT	d3 GTCGGCTGGCG	d4 AGTACTGCCG				
4	X Coordinate: 45	Y Coordinate: 24	d1 ACTGTGTACG	d2 GCATGGCGTGT	d3 CTGCCGCTCTG	d4 AGATTGGCAG				
5	X Coordinate: 46	Y Coordinate: 24	d1 ACCTACACCA	d2 TCGCGGCGTGT	d3 CGACCATAGCG	d4 ATGTCGATAT				
6	X Coordinate: 49	Y Coordinate: 52	d1 TGCGAGCTGT	d2 ATGGTCATGCT	d3 CTGTACCGCTG	d4 AGGTCATGCG				
7	X Coordinate: 47	Y Coordinate: 55	d1 CATCTGTGCTC	d2 GCATTACGAT	d3 TCAGGAATCG	d4 ATCAGTACTCC				
8	X Coordinate: 46	Y Coordinate: 55	d1 CGTACCGTGCT	d2 GCCGCTTCGT	d3 CACTTATACA	d4 AACATGGCAGC				
9	X Coordinate: 45	Y Coordinate: 56	d1 GTAGACGTGT	d2 TAGTGATACCT	d3 TGCATATGTCG	d4 AACTTCACAG				
10	X Coordinate: 45	Y Coordinate: 58	d1 ATACATCGAT	d2 TGAGAGCATTT	d3 TGTCATTGTAG	d4 AGCAAGGTGA				
11	X Coordinate: 41	Y Coordinate: 76	d1 AGATGTGAAA	d2 CTCTAACACTT	d3 GCGTTGGTGAG	d4 AGATATCGTA				
12	X Coordinate: 44	Y Coordinate: 78	d1 GTCAGTCTCT	d2 GATGTCGAGGT	d3 TCACCGTGGTG	d4 AGCTTAACAC				
13	X Coordinate: 46	Y Coordinate: 78	d1 TCAGGTGTGA	d2 CCGACGAGTAT	d3 GATAGATCTCG	d4 ATGAACCGAG				
14	X Coordinate: 47	Y Coordinate: 78	d1 AGTCAGCGCG	d2 TTATAGAAGGT	d3 GTGAAGCGCGG	d4 AGTCTGACTA				
15	X Coordinate: 48	Y Coordinate: 78	d1 TCCTGTATGC	d2 AGATCCGTCTT	d3 ATCTACAGCGG	d4 AGGACAGCGC				
16	X Coordinate: 49	Y Coordinate: 78	d1 CGCTCGCTAA	d2 CTCTGGAGAAT	d3 ACACCTACCAG	d4 AGATCGATGT				
17	X Coordinate: 53	Y Coordinate: 64	d1 TAACTGCGCC	d2 GCTGATAGAGT	d3 TATCGAATGCG	d4 AATGACACGT				
18	X Coordinate: 51	Y Coordinate: 60	d1 TACGTCGAAC	d2 ATAGCAGCGTT	d3 TGCGGAAGAGG	d4 ATTCCACTTA				
19	X Coordinate: 48	Y Coordinate: 54	d1 CGATTCCTGA	d2 ATGGACTTCGT	d3 CTAGCTCTAGG	d4 AGGTCGTATA				
20	X Coordinate: 47	Y Coordinate: 54	d1 TGTATAAGTG	d2 GGAGTACTGAT	d3 AGTCTCAGGCG	d4 ACGCAGTGGA				
21	X Coordinate: 46	Y Coordinate: 54	d1 AGGTAGACCG	d2 GCTGCCATGTT	d3 CGTATCTATCG	d4 ATCTAGTGAG				
22	X Coordinate: 45	Y Coordinate: 55	d1 CACTCAGTGTG	d2 CTGATGCGGT	d3 CGGTCTACCT	d4 ATCATACGGCG				
23	X Coordinate: 44	Y Coordinate: 57	d1 CCTCTCATGTG	d2 CAGTGTCGAT	d3 ACACGTCTAC	d4 ATCAGCCACTT				
24	X Coordinate: 42	Y Coordinate: 57	d1 CATCTCTTGCT	d2 TCACCTTGCT	d3 AACTTGGTGC	d4 AGGCCTAGCGG				
25	X Coordinate: 41	Y Coordinate: 56	d1 TCTCGCGCCT	d2 CGCGAGCTCTT	d3 CGACACTCTGG	d4 AGATGCCATC				
26	X Coordinate: 39	Y Coordinate: 55	d1 CCAGAGTGTCG	d2 CTGCCTCTTT	d3 GGCATGACGC	d4 AGTCAGATAGC				
27	X Coordinate: 39	Y Coordinate: 53	d1 CGACGTAGTGC	d2 TCTATGTGAT	d3 CTATCATGTC	d4 ATAGGAGATCA				
28	X Coordinate: 38	Y Coordinate: 51	d1 CGCCGTGTGTC	d2 AGAGATCAGT	d3 GGTCTACTCA	d4 AAGATACTGCC				
29	X Coordinate: 38	Y Coordinate: 50	d1 TAGACGACCA	d2 GGCAGTATCTT	d3 CGTACAACCAG	d4 ACACGTATAC				
30	X Coordinate: 38	Y Coordinate: 49	d1 CGTTACTTACG	d2 CGAGTAGTTT	d3 ACTCAGGCGC	d4 AGATATGCCAG				
31	X Coordinate: 38	Y Coordinate: 48	d1 AGGCAGGCAT	d2 CTGGCATATCT	d3 ATGCCGATGAG	d4 ACTATCGAAG				

Figure 6 Sample DNA detailed output file

Help Menu

"Help" menu which is very common in any software. There are four options in the Help Menu.

1. User Manual
2. Product Demo
3. Product Feedback
4. About

- First option, user manual should open this user manual in the default PDF reader of user's system.
- Second option product demo will open the homepage of DNA Pen where the demo is available.
- Third option will open the feedback form where you can give feedback for the software.
- Finally about option recognize the contributors in this project. There is a dialog box that opens up as shown below, which contains information like logo of the software, version of the software, name of the software, Credits button and URL of the software. On pressing "Credits", it opens a PDF document in user's default PDF reader.

Support and Feedback

Users are requested to contact team at the email: dnapen@guptalab.org for feedback and any other issues with the software. Two platform specific installers (Windows and Mac) are available on the project home page along with source code with open source license agreement.

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