Data Structure Visualization

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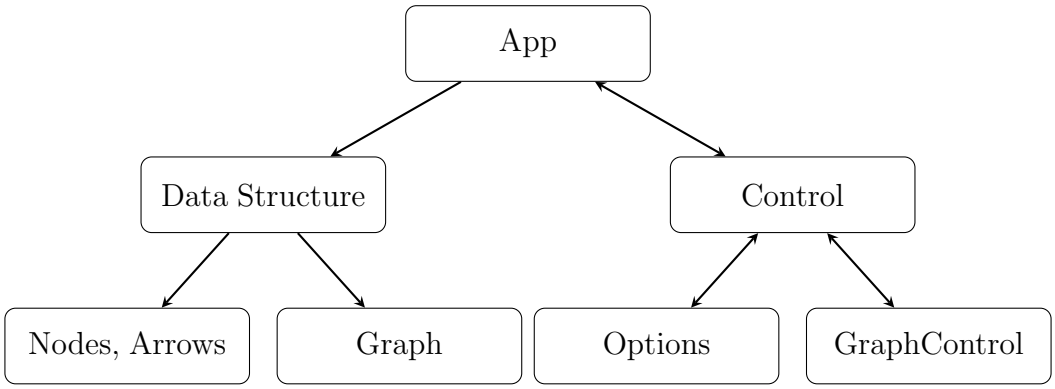
Contents

1 Program structures

1.1 Overview



1.2 Description

- Graph:
  - Graph manages to do steps in order.
  - Each step has a time interval for drawing and contains draw functions of nodes and arrows.
  - The order of draw functions is arranged so that in a frame, chosen nodes and arrows should be drawn on screen properly.
- Control: it contains Options and GraphControl
  - Options: contais several buttons such as Create, Insert, Search, Update, Delete, ...
  - GraphControl: contains several buttons such as Play, Pause, NextStep, PrevStep, GoToBegin, GoToEnd.

1.3 Work flow

When user click a button, the **Options** or **GraphControl** receives that and sends a command to **Control**. In every frame, **Control** asks **App** to execute the commands which are waiting. Those commands can be Create, Insert, Play, Pause, ... If there is a command is waiting, **App** will execute that by calling according functions in **Data Structure** and remove that command.

1.4 Details

1.4.1 Class App

1. `App();`
   - Inits window configuration.
   - Loads font, background image.
2. `~App();`
   - Deletes dynamically allocated memory of **Data Structure**.
3. `void processInput();`
   - Transfers events from window to **Control** so that **Control** knows whether a button is clicked.
   - Handles when user want to exit the application.
4. `void update();`

- Calls update functions of **Data Structure**.

5. `void draw();`
   - Calls draw function of **Graph** and draw background.
6. `void run();`
   - Handles while loop of `processInput(); update(); draw();`, which is frame over frame.
7. `void SLL_Update(); void DLL_Update();...`
   - Receives commands from `Control`.
   - Calls consistent functions of **Data Structure** such as **Create, Insert, Search, ...**

1.4.2 Class Control

1. `Control();`
   - Loads option's button background image.
   - Loads suboption's button background image.
   - Loads **Play, Pause, ...** button background image.
2. `void handleEvent(sf::Event& event, sf::RenderWindow* window);`
   - Receives events from **App**.
   - Generates a command if a button is clicked.
3. `void update(float dt);`
   - Calls update function of **InputBox** so that the cursor in the input box appears or disappears with respect of time `dt`.
4. `bool getCommand(Command& command);`
   - If there is at least a command in the `commandQueue`, that command will be assigned to `command` and return true.
   - On the other hand, return false.
5. `void loadSubOption();`
   - Loads corresponding suboptions if a option's button is clicked.
6. `void draw(sf::RenderTarget& target, sf::RenderStates states) const;`
   - Calls draw function of option's buttons
   - Calls draw function of suboption's buttons.
   - Calls draw function of **Play, NextStep, PrevStep, ...** buttons.

1.4.3 Struct Node

1. `Node(int val, sf::Vector2f pos);`
   - Init node's value and position on the window.
   - **Parameter**:
     - `val`: the initial value.
     - `pos`: the initial position.
2. `void drawCircle(sf::RenderWindow* window, sf::CircleShape* circle, sf::Color inColor, sf::Color outColor, sf::Text* num, sf::Color numColor);`

- Draw node on the window with given parameters.
- **Parameter**
  - `window`: the pointer of current window.
  - `circle`: the shape of circle (is generated in **Graph**).
  - `inColor`: the inside color.
  - `outColor`: the outline color.
  - `num`: the text is num represented in string.
  - `numColor`: the text's color of value of that node.

3. `void drawCircleGrow(sf::RenderWindow* window, sf::CircleShape* circle, sf::Color inColor, sf::Color outColor, sf::Text* num, sf::Color numColor, float percent);`
   - Draw node on the window with given parameters.
   - As the time goes by (`percent` increases gradually), the size of the circle will grow by multiplying `percent` with the radius.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `circle`: the shape of circle (is generated in **Graph**).
     - `inColor`: the inside color.
     - `outColor`: the outline color.
     - `num`: the text is num represented in string.
     - `numColor`: the text's color of value of that node.
     - `percent`: the percentage of the size of the circle ($0 \leq$ `percent` ≤ 1).
4. `void drawCircleshrink(sf::RenderWindow* window, sf::CircleShape* circle, sf::Color inColor, sf::Color outColor, sf::Text* num, sf::Color numColor, float percent);`
   - Draw node on the window with given parameters.
   - As the time goes by (`percent` decreases gradually), the size of the circle will shrink by multiplying `percent` with the radius.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `circle`: the shape of circle (is generated in **Graph**).
     - `inColor`: the inside color.
     - `outColor`: the outline color.
     - `num`: the text is num represented in string.
     - `numColor`: the text's color of value of that node.
     - `percent`: the percentage of the size of the circle ($0 \leq$ `percent` ≤ 1).
5. `void drawCircleFadeIn(sf::RenderWindow* window, sf::CircleShape* circle, sf::Color inColor, sf::Color outColor, sf::Text* num, sf::Color numColor, float percent);`
   - Draw node on the window with given parameters.
   - As the time goes by (`percent` increases gradually), the opacity of the circle will increase by setting the alpha=`percent`$\cdot$255 of the RGBA color.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `circle`: the shape of circle (is generated in **Graph**).
     - `inColor`: the inside color.
     - `outColor`: the outline color.

  - `num`: the text is num represented in string.
  - `numColor`: the text's color of value of that node.
  - `percent`: the percentage of the opacity of the circle ($0 \leq$ `percent` ≤ 1).

6. `void drawCircleFadeOut(sf::RenderWindow* window, sf::CircleShape* circle, sf::Color inColor, sf::Color outColor, sf::Text* num, sf::Color numColor, float percent);`
   - Draw node on the window with given parameters.
   - As the time goes by (`percent` decreases gradually), the opacity of the circle will decrease by setting the alpha=`percent`$\cdot 255$ of the RGBA color.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `circle`: the shape of circle (is generated in **Graph**).
     - `inColor`: the inside color.
     - `outColor`: the outline color.
     - `num`: the text is num represented in string.
     - `numColor`: the text's color of value of that node.
     - `percent`: the percentage of the opacity of the circle ($0 \leq$ `percent` ≤ 1).
7. `void drawCircleMove(sf::RenderWindow* window, sf::Vector2f src, sf::Vector2f dest, sf::CircleShape* circle, sf::Color inColor, sf::Color outColor, sf::Text* num, sf::Color numColor, float percent);`
   - Draw node on the window with given parameters.
   - As the time goes by (`percent` decreases gradually), the size of the circle will go from `src` to `dest` by multiplying `percent` with the length of the path.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `circle`: the shape of circle (is generated in **Graph**).
     - `inColor`: the inside color.
     - `outColor`: the outline color.
     - `num`: the text is num represented in string.
     - `numColor`: the text's color of value of that node.
     - `percent`: the percentage of the size of the circle ($0 \leq$ `percent` ≤ 1).
8. The draw functions of square figure are similar to the draw functions of circle figure (1-7).
9. `void drawSubscript(sf::RenderWindow* window, sf::Text* text, std::string str, sf::Color textColor, SubscriptDir dir);`
   - Draw subscript besides node on the window with given parameters.
   - **Parameter**
     - `window`: the pointer of current window.
     - `text`: the pointer of text figure.
     - `str`: the subscript's string.
     - `textColor`: the text's color.
     - `dir`: position of the subscript with respect to the position of the chosen node `(UP/ DOWN/ LEFT/ RIGHT)`.

1.4.4 Struct Arrow

1. `Arrow(sf::Vector2f src, sf::Vector2f dest, bool flag);`
   - Set the source node and destination node of the arrow.
   - **Parameter**:
     - `src`: the source node.
     - `dest`: the destination node.
     - `flag`: the flag to determine it's for Singly Linked List or Doubly Linked List.
2. `void update(ArrowFigure* arrowFig);`
   - Update the arrow's position, length, rotation.
   - **Parameter**:
     - `arrowFig`: the pointer of arrow figure.
3. `void draw(sf::RenderWindow* window, ArrowFigure* arrowFig, sf::Color color);`
   - Draw the arrow on the window with given parameters.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `arrowFig`: the pointer of arrow figure.
     - `color`: the color of the arrow.
4. `void drawGrow(sf::RenderWindow* window, ArrowFigure* arrowFig, sf::Color color, float percent);`
   - Draw the arrow on the window with given parameters.
   - As the time goes by (`percent` increases gradually), the size of the arrow will grow by multiplying `percent` with the length of the arrow.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `arrowFig`: the pointer of arrow figure.
     - `color`: the color of the arrow.
     - `percent`: the percentage of the size of the arrow ($0 \leq$ `percent` ≤ 1).
5. `void drawShrink(sf::RenderWindow* window, ArrowFigure* arrowFig, sf::Color color, float percent);`
   - Draw the arrow on the window with given parameters.
   - As the time goes by (`percent` decreases gradually), the size of the arrow will shrink by multiplying `percent` with the length of the arrow.
   - **Parameter**:
     - `window`: the pointer of current window.
     - `arrowFig`: the pointer of arrow figure.
     - `color`: the color of the arrow.
     - `percent`: the percentage of the size of the arrow ($0 \leq$ `percent` ≤ 1).
6. `void drawFadeIn(sf::RenderWindow* window, ArrowFigure* arrowFig, sf::Color color, float percent);`
   - Draw the arrow on the window with given parameters.
   - As the time goes by (`percent` increases gradually), the opacity of the arrow will increase by setting alpha=`percent`$\cdot 255$ in RGBA color.
   - **Parameter**:

    - `window`: the pointer of current window.
    - `arrowFig`: the pointer of arrow figure.
    - `color`: the color of the arrow.
    - `percent`: the percentage of the opacity of the arrow ($0 \leq$ `percent` ≤ 1).

7. `void drawFadeOut(sf::RenderWindow* window, ArrowFigure* arrowFig, sf::Color color, float percent);`
    - Draw the arrow on the window with given parameters.
    - As the time goes by (`percent` decreases gradually), the opacity of the arrow will decrease by setting alpha=`percent`·255 in RGBA color.
    - **Parameter**:
        - `window`: the pointer of current window.
        - `arrowFig`: the pointer of arrow figure.
        - `color`: the color of the arrow.
        - `percent`: the percentage of the opacity of the arrow ($0 \leq$ `percent` ≤ 1).

1.4.5 Class Graph

1. `Graph();`
    - Get window pointer and font from **App**.
2. `void clear();`
    - Clear all steps.
    - Set `curFrame=curStep=0`.
3. `void Graph::finishAllSteps();`
    - Finish all steps and clear all previous draw functions.
4. `void addStep(int frames);`
    - Add new step in `drawFunc`
    - **Parameter**:
        - `frames`: Number of frames of added step.
5. `void goToBegin();`
    - Go to the first step.
6. `void goToEnd();`
    - Go to the last step.
7. `bool isDoneAllSteps();`
    - Check if the last step is done or not.
8. `void nextStep();`
    - Finish current step and execute next step.
9. `void prevStep();`
    - Finish current step and execute previous step.
10. `void setVisualDir(VisualDir d);`
    - Set visual direction `(FORWARD/ BACKWARD)`.
    - **Parameter**

    - `d`: visual direction.

11. `void setVisualType(VisualType t);`
    - Set visual type `(AUTO, STEP_BY_STEP)`.
    - **Parameter**
      - `t`: visual type.

12. `void draw(Node* node, NodeType type, sf::Color inColor, sf::Color outColor, sf::Color numColor);`
    - Push back `draw` function of `node` in `drawFunc`.
    - **Parameter**
      - `node`: the pointer of chosen node.
      - `type`: shape of the node `(SQUARE/ CIRCLE)`.
      - `inColor`: the inside color.
      - `outColor`: the outline color.
      - `numColor`: the text's color of value of that node.

13. `void drawGrow(Node* node, NodeType type, sf::Color inColor, sf::Color outColor, sf::Color numColor);`
    - Push back `drawGrow` function of `node` in `drawFunc`.
    - **Parameter**
      - `node`: the pointer of chosen node.
      - `type`: shape of the node `(SQUARE/ CIRCLE)`.
      - `inColor`: the inside color.
      - `outColor`: the outline color.
      - `numColor`: the text's color of value of that node.

14. `void drawShrink(Node* node, NodeType type, sf::Color inColor, sf::Color outColor, sf::Color numColor);`
    - Push back `drawShrink` function of `node` in `drawFunc`.
    - **Parameter**
      - `node`: the pointer of chosen node.
      - `type`: shape of the node `(SQUARE/ CIRCLE)`.
      - `inColor`: the inside color.
      - `outColor`: the outline color.
      - `numColor`: the text's color of value of that node.

15. `void drawFadeIn(Node* node, NodeType type, sf::Color inColor, sf::Color outColor, sf::Color numColor);`
    - Push back `drawFadeIn` function of `node` in `drawFunc`.
    - **Parameter**
      - `node`: the pointer of chosen node.
      - `type`: shape of the node `(SQUARE/ CIRCLE)`.
      - `inColor`: the inside color.
      - `outColor`: the outline color.
      - `numColor`: the text's color of value of that node.

16. `void drawFadeOut(Node* node, NodeType type, sf::Color inColor, sf::Color outColor, sf::Color numColor);`
    - Push back `drawFadeOut` function of `node` in `drawFunc`.

- **Parameter**
  - `node`: the pointer of chosen node.
  - `type`: shape of the node `(SQUARE/ CIRCLE)`.
  - `inColor`: the inside color.
  - `outColor`: the outline color.
  - `numColor`: the text's color of value of that node.

17. `void drawSubscript(Node* node, std::string str, sf::Color textColor, SubscriptDir dir=DOWN);`
    - Push back `drawSubscript` function of `node` in `drawFunc`.
    - **Parameter**
      - `node`: the pointer of chosen node.
      - `str`: the subscript's string.
      - `textColor`: the text's color.
      - `dir`: position of the subscript with respect to the position of the chosen node `(UP/ DOWN/ LEFT/ RIGHT)`.
18. `void draw(Arrow* arrow, sf::Color color);`
    - Push back `draw` function of `arrow` in `drawFunc`.
    - **Parameter**
      - `arrow`: the pointer of the chosen arrow.
      - `color`: the color of the arrow.
19. `void drawGrow(Arrow* arrow, sf::Color color);`
    - Push back `drawGrow` function of `arrow` in `drawFunc`.
    - **Parameter**
      - `arrow`: the pointer of the chosen arrow.
      - `color`: the color of the arrow.
20. `void drawShrink(Arrow* arrow, sf::Color color);`
    - Push back `drawShrink` function of `arrow` in `drawFunc`.
    - **Parameter**
      - `arrow`: the pointer of the chosen arrow.
      - `color`: the color of the arrow.
21. `void drawFadeIn(Arrow* arrow, sf::Color color);`
    - Push back `drawFadeIn` function of `arrow` in `drawFunc`.
    - **Parameter**
      - `arrow`: the pointer of the chosen arrow.
      - `color`: the color of the arrow.
22. `void drawFadeOut(Arrow* arrow, sf::Color color);`
    - Push back `drawFadeOut` function of `arrow` in `drawFunc`.
    - **Parameter**
      - `arrow`: the pointer of the chosen arrow.
      - `color`: the color of the arrow.
23. `void draw(CodeBox* codeBox, int pos);`
    - Push back `draw` function of `codeBox` in `drawFunc`.

- **Parameter**
  - `codeBox`: the pointer of the chosen code box.
  - `pos`: the line number to be highlighted.

24. `void draw();`
    - Calls all draw functions of current step that was pushed to `drawFunc`.

1.4.6 Other class/struct

There are more classes or structs in the application that are not mentioned above. They are:

1. `Struct Figure`: generate the figure of cirle, square, and arrow.
2. `Struct List`: manage properties and methods of the list of elements (node/arrow).
3. `Struct ListElement`: manage properties and methods of a element (node/arrow).
4. `Class ArrowFigure`: manage properties and methods of the arrow figure.
5. `Class Button`: generate, manage properties and methods of a button.
6. `Class CodeBox`: generate, manage properties and methods of a code box.
7. `Class Graph_Control`: manage methods of the graph control.
8. `Class InputBox`: generate, manage properties and methods of a input box.
9. `Class Menu`: generate, manage properties and methods of a menu.
10. `Class TextBox`: generate, manage properties and methods of a text box.
11. `Class SLL_Control, Class DLL_Control, ...`: manage the options, suboptions, and commands.

The reason why I do not write detail about them is that they are not important as the classes/structs mentioned above. They are just used to support the application.

2 Functional DS

There are several abbrivation of the name of the data structures in the table:

1. **SLL**: Singly Linked List.
2. **DLL**: Doubly Linked List.
3. **CLL**: Circular Linked List.
4. **SArr**: Static Array.
5. **DArr**: Dynamic Array.

There are notes in the table such as:

- ✓: the function was developed.
- ⊕: the function has been developing.
- ×: the function has not been done.

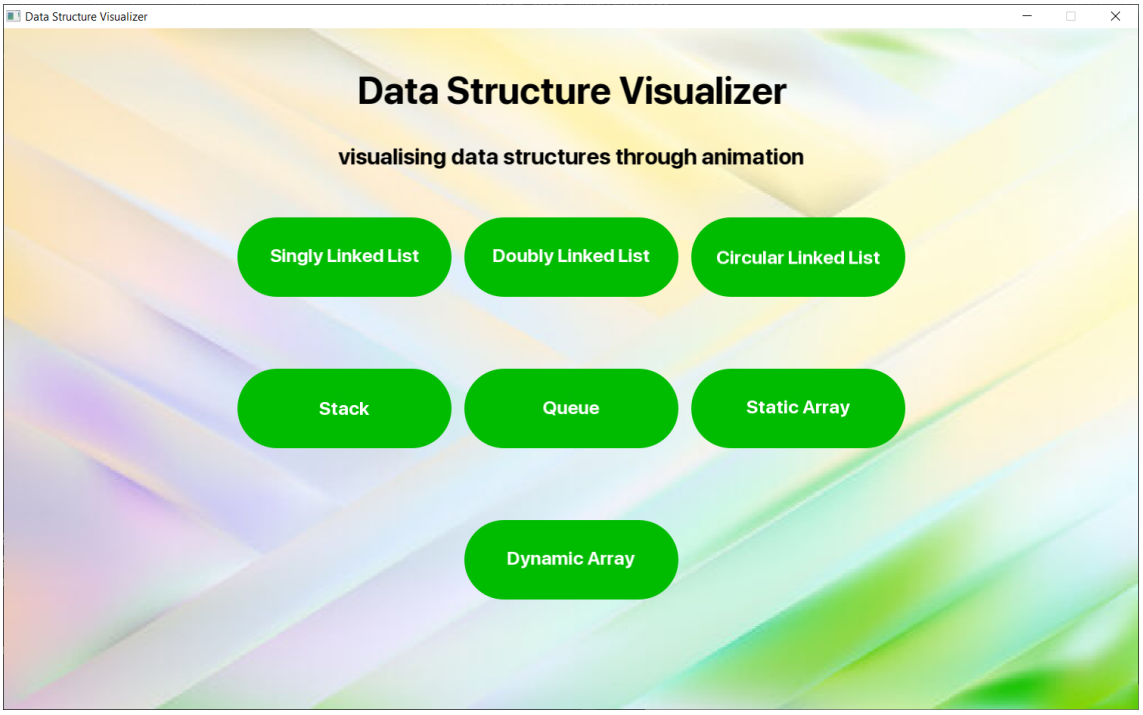
Functions \ Data Structures		Stack	Queue
Create	Empty Manual Random Random fixed size Load from file	✓	✓
Push		✓	✓
Pop		✓	✓
Top/Front		✓	✓

Functions \ Data Structures		SLL	DLL	CLL	SArr	DArr
Create	Empty Manual Random Random fixed size Load from file	✓	✓	×	✓	✓
Insert	At the first After the last In the middle	✓	✓	×	✓	✓
Delete	The first The last In the middle	✓	✓	×	✓	✓
Update		✓	✓	×	✓	✓
Search		✓	✓	×	✓	✓

3 User's manual

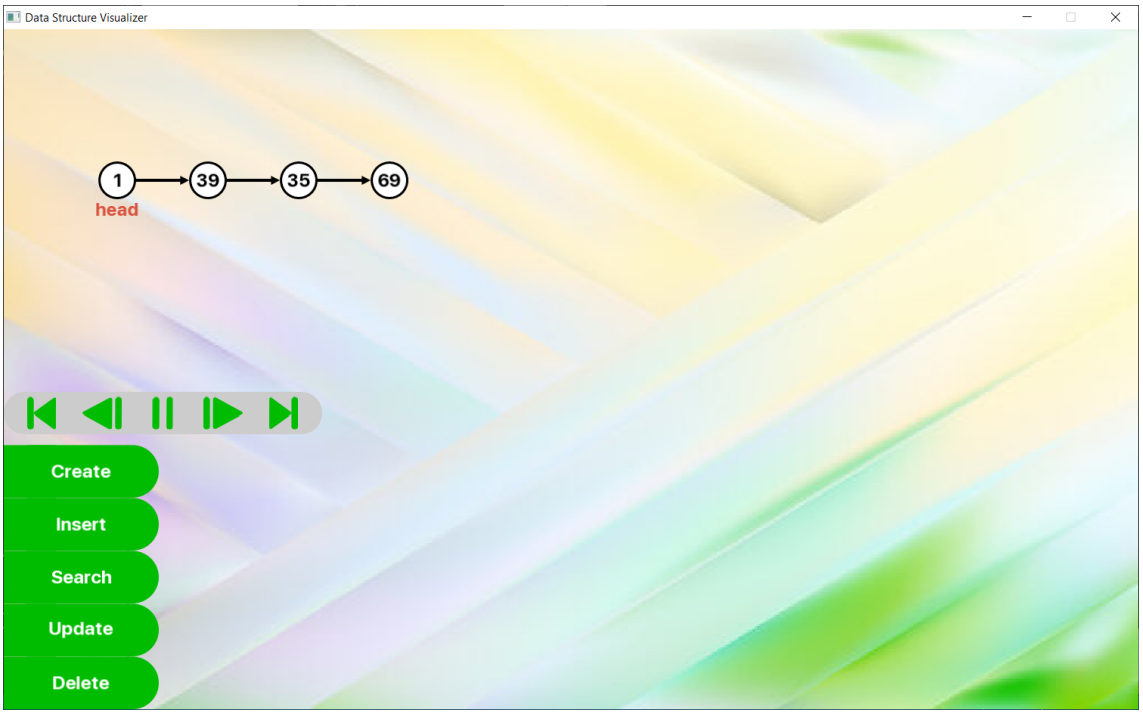
3.1 Main menu

In order to start the application, you need to run the file `DSV.exe` in the folder `Release`. This is the dash board of the application:



3.2 Singly Linked List

If you choose `Singly Linked List` by clicking the button `Singly Linked List`, you will see the following window:



3.2.1 Graph Control

From left to right we have buttons which are:

1. Go to the begining of the animation.
2. Go to previous step.
3. Play/Pause the animation.
4. Go to next step.
5. Go to the end of the animation.

3.2.2 Operations

1. **Create**:
   (a) **Empty**: create an empty list.
   (b) **Manual**: create a list by inputing elements.
   (c) **Random**: create a list by random elements.
   (d) **Random fixed size**: create a list by random elements with a fixed size.
   (e) **Load from file**: create a list by loading from a file.

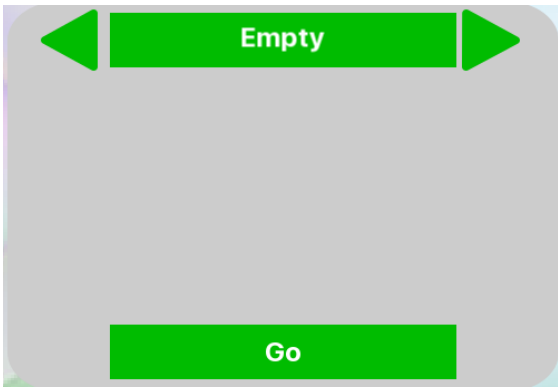


Figure 1: (a)

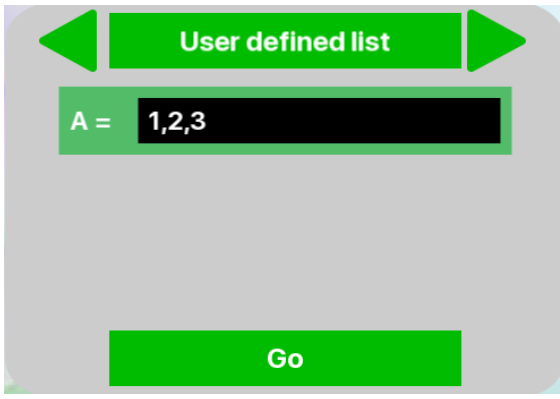


Figure 2: (b)

Figure 3: (c)

Figure 4: (d)

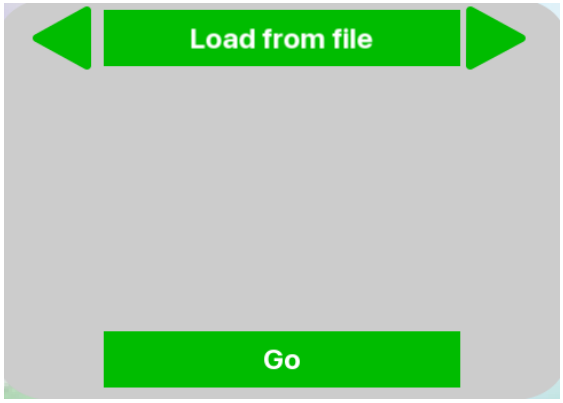


Figure 5: (d)

You can switch between options by clicking the triangle buttons.

If you want to perform the operation, click the button `Go`.

2. **Insert**:

   (a) **At the first**: insert `v` at the first position.

   (b) **After the last**: insert `v` after the last position.

   (c) **In the middle**: insert `v` at the position `i`.

   Constraints:

   - `v` must be an integer and `v` $\in [0, 99]$.
   - `i` must be an integer and `i` $\in [0, \text{size} - 1]$.

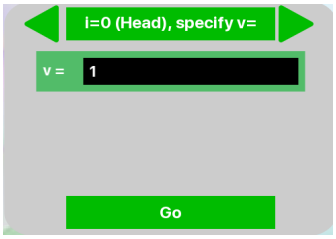


Figure 6: (a)

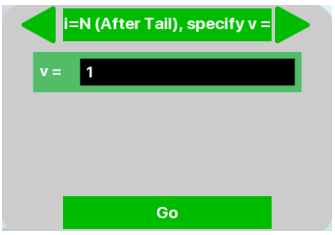


Figure 7: (b)

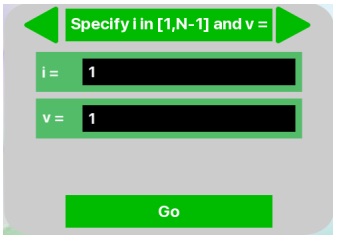
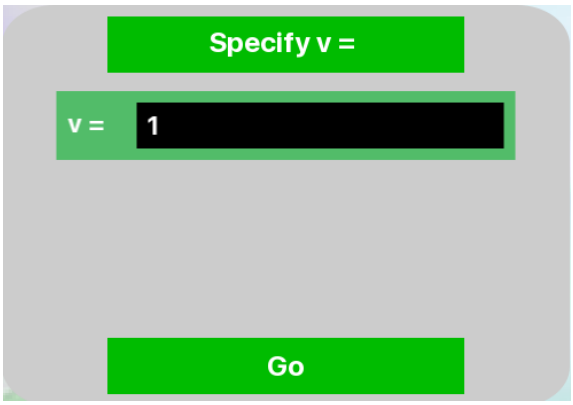


Figure 8: (c)

3. **Search**: search `v` in the list.

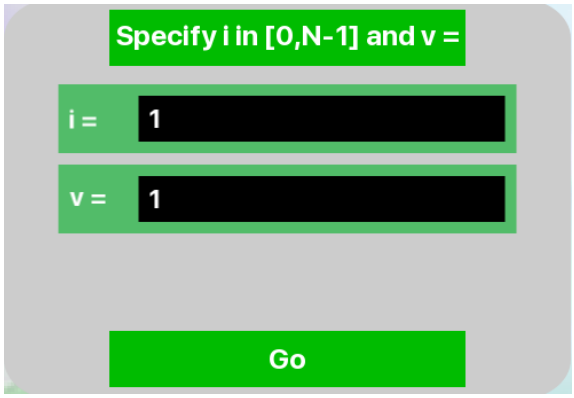
   Constraints: `v` must be an integer and `v` $\in [0, 99]$.



4. **Update**: update the value of the node at the position `i` to `v`.

   Constraints:

   - `v` must be an integer and `v` $\in [0, 99]$.
   - `i` must be an integer and `i` $\in [0, \text{size} - 1]$.



5. **Delete**:

   (a) **The first**: delete the first node.

   (b) **The last**: delete the last node.

   (c) **In the middle**: delete the node at the position `i`.

   Constraints: `i` must be an integer and `i` $\in [0, \text{size} - 1]$.

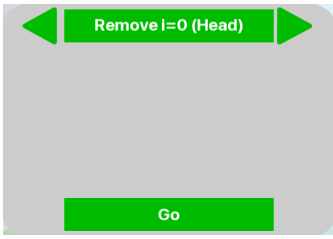


Figure 9: (a)

Figure 10: (b)

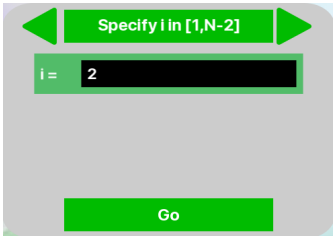


Figure 11: (c)

You can see some examples of animation below:

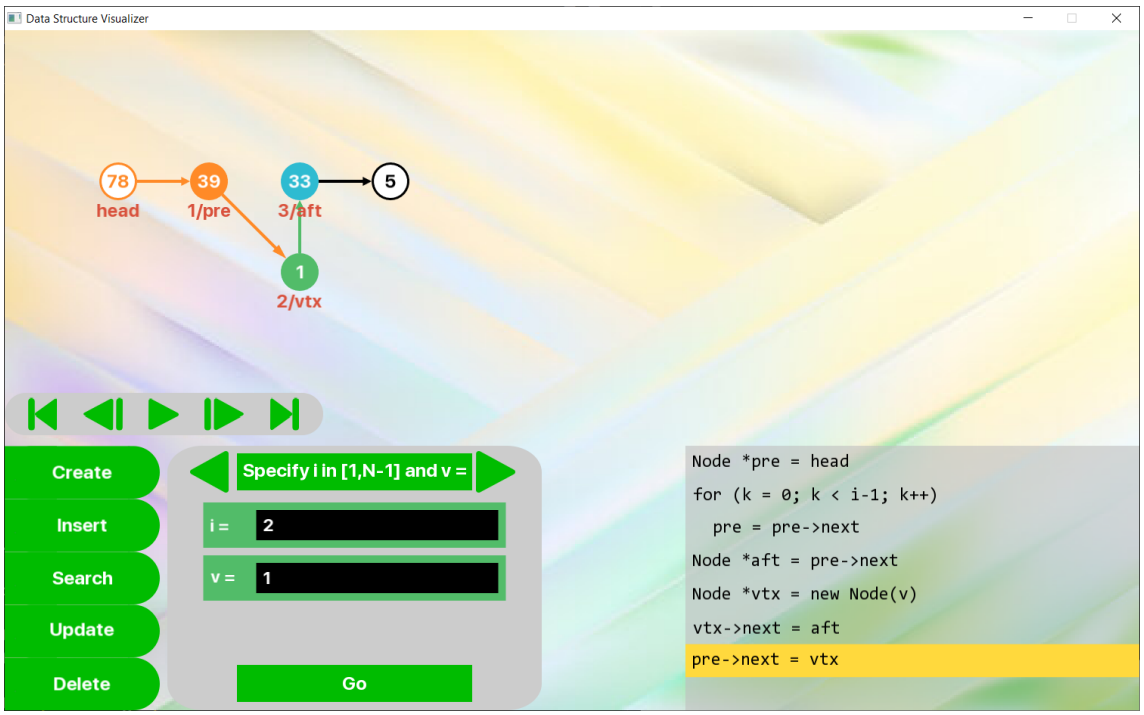


Figure 12: Inserting a node has value 1 at position 2

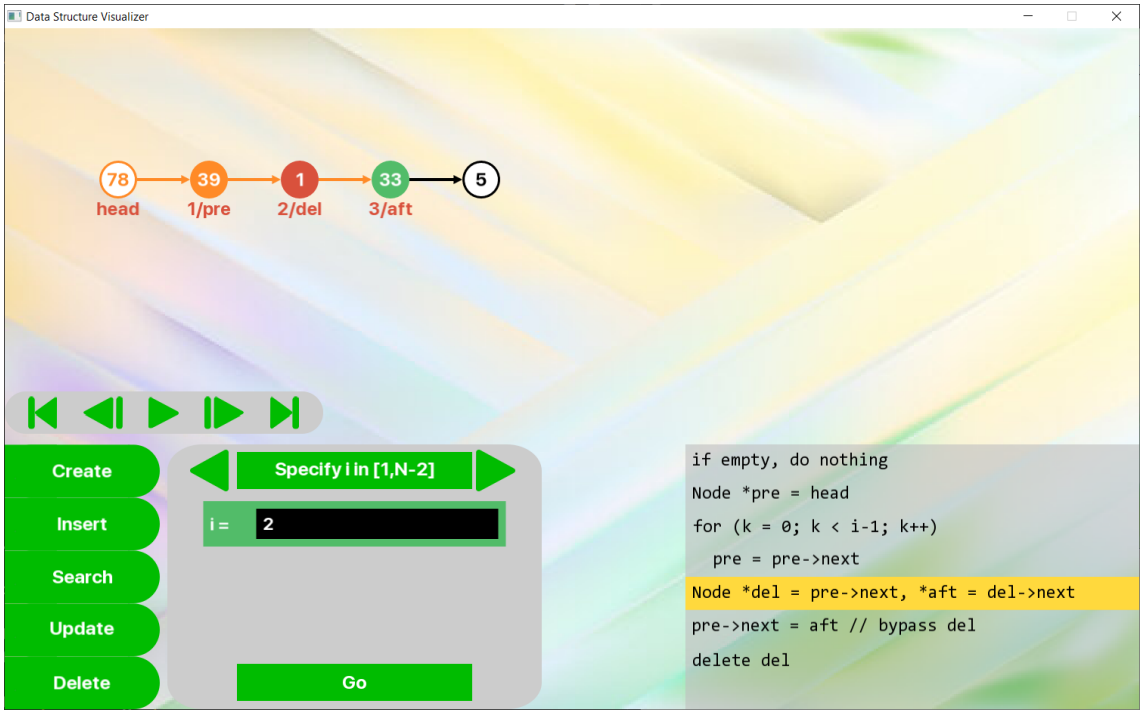


Figure 13: Deleting a node at position 2

Press **Esc** to go back to the main menu.
Press **Alt-F4** or click the **X** button on the top right corner to exit the program.
Other data structures have similar appearance and operations.

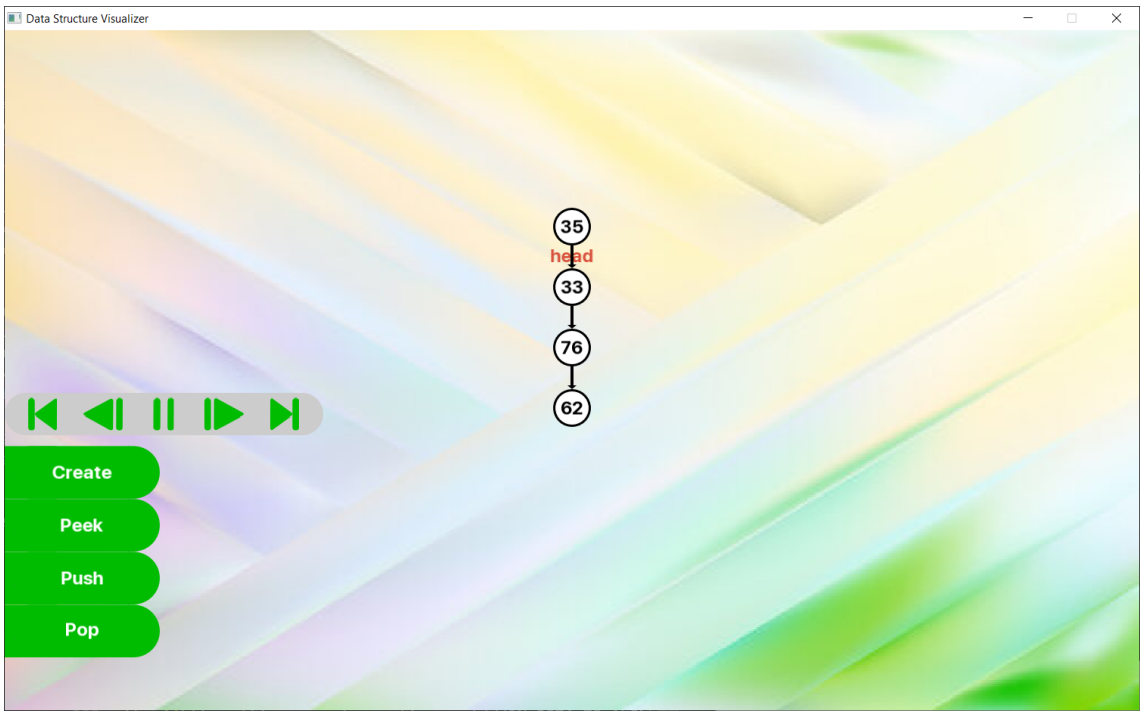


Figure 14: Stack

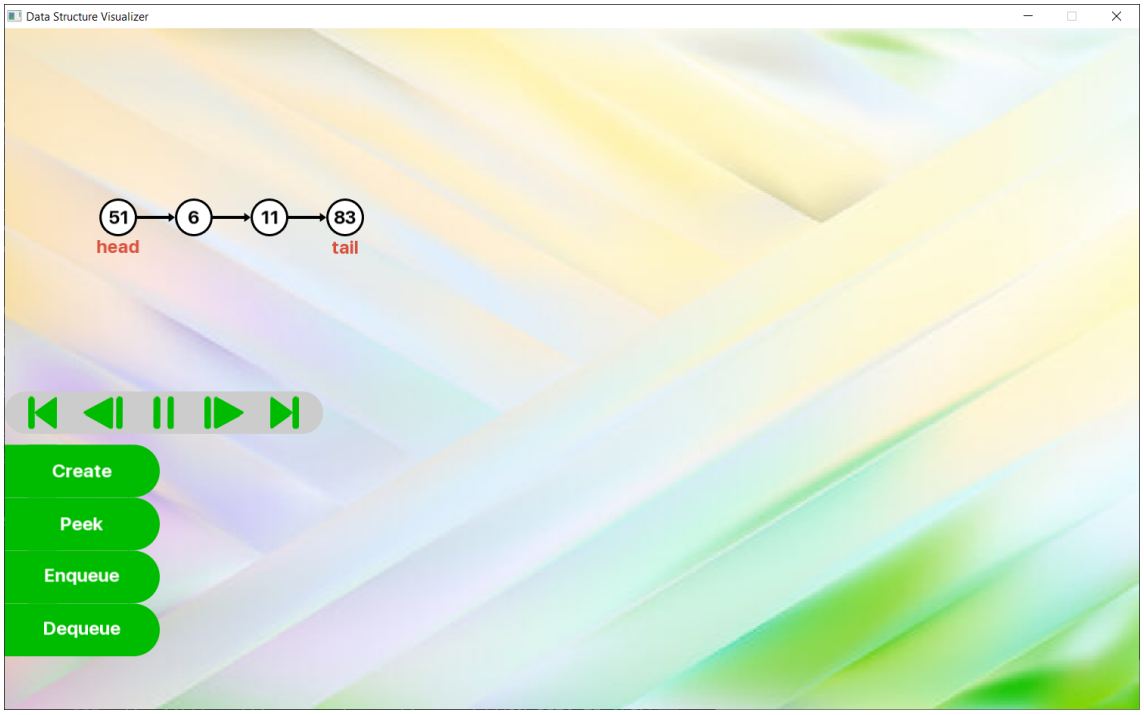


Figure 15: Queue

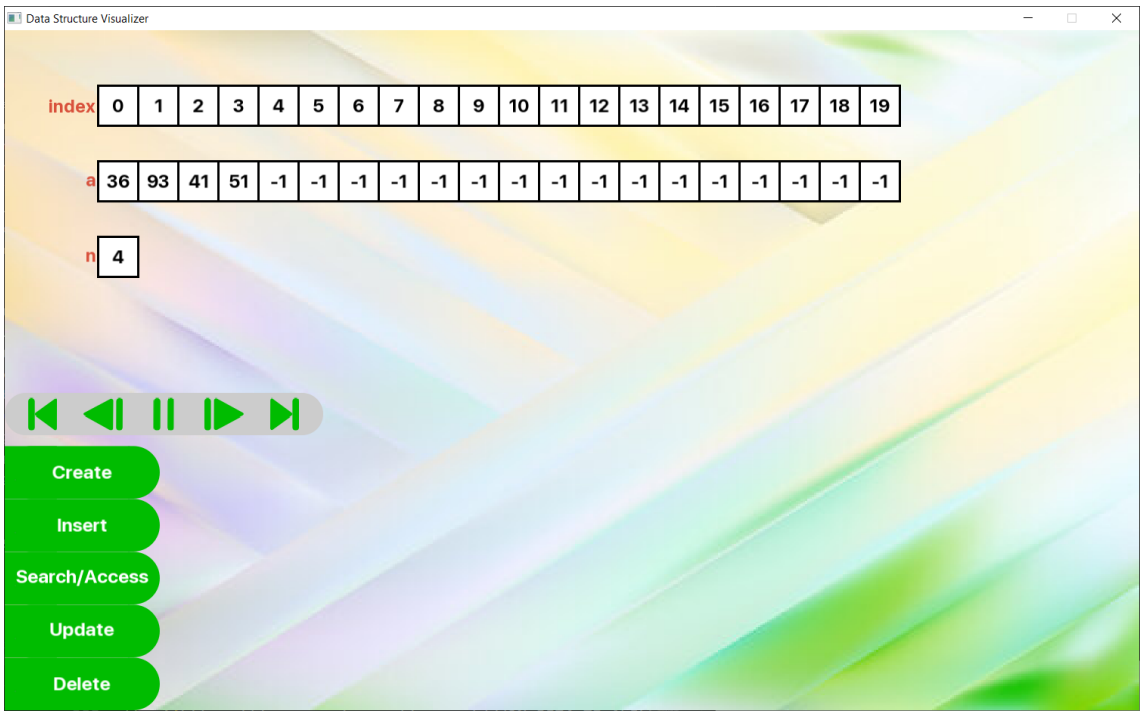


Figure 16: Static Array

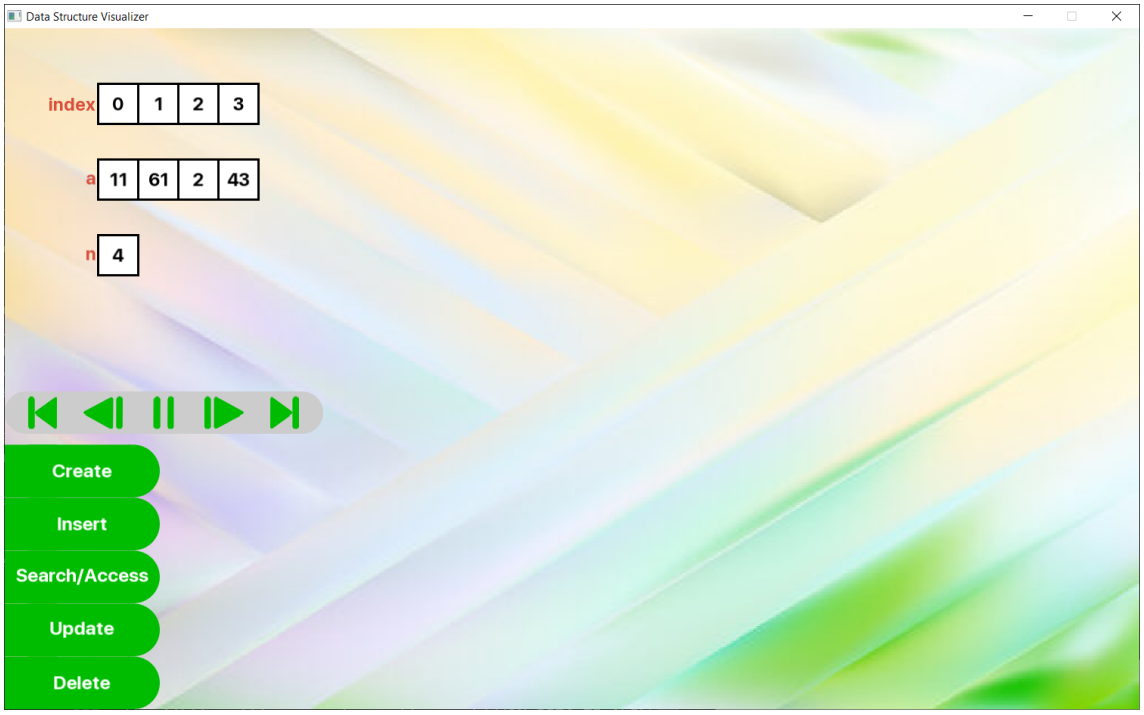


Figure 17: Dynamic Array

4 Commit list

https://docs.google.com/document/d/1No2OZ4w78wAb2kXCmfLugrSHtgGDN4zQazmpcmGRgjM/edit?usp=sharing

5 Link of git

https://github.com/slo248/CS162_DS_Visualizer.git

6 Link of demo video

https://youtu.be/Y-MI91RW8B8