



UNIVERSITY OF LIVERPOOL

COMPUTER SCIENCE WITH A YEAR IN INDUSTRY BSc (HONS)

G403

COMP390 Honours Year Computer Science Project Design Specification

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Chapter 1

Overview

1.1 Project description

This project primarily focuses on the animation of different types of commonly used algorithms, for the benefit of users to further understand how algorithms work in general. The scope of this project is within the animation of the main algorithmic paradigms, divide and conquer, greedy method, and dynamic programming.

Learning about what algorithms are and how they work is essential for students who are studying computer science. Since this project is meant to be educational, the target audience of the software will be students studying computer science, or at least have an interest on how computer programs are made efficient.

This project is to develop a software that displays animations that shows how an algorithmic solution works in general. From the program, the users are able to pick the algorithmic solution they wish to learn, enter a certain amount of input, or generate random values, and then learn how the algorithm works by watching the animations presented to them.

1.2 Aims and objectives of this project

The primary objective to this project is simply to make difficult algorithms easily understood. Also, using of visual aid as part of the educational process, for instance animations, to enhance the users' learning experience, which will make the students to learn new algorithmic problems with convenience and ease.

It is generally known the algorithms is one of challenging topics within the computer science field that is difficult for students to grasp on. So, the aim for this project is to allow students to achieve greater understanding in algorithmic paradigms, by providing an animated explanation in a step by step basis. To achieve this, the animation is to allow further speculation on how it works step by step, by breaking it down into smaller parts. This strategy of scrutinizing the algorithm allows the users to speculate the complicated algorithms in its granulated state, on how it works in each step, and then making a connection between the sequence of steps that makes the algorithm work as a whole.

Another aim for this project, is to provide the basic idea of how an educational program is suppose to look and work like in order to successfully assist the students. As a computer science student myself, I understand what are the specific difficulties when it comes to learning algorithms, and using them to address every difficulty I had when learning algorithms for the first time. Hopefully, once this project is completed, it will show the other developers who are interested in taking on this project on the specific areas to pay attention to when developing an educational program like this one.

I have also intend to serve this program as a base, where other developers could use to iterate from, by populating the list of available algorithms, by adding other algorithms into the list. If the project is deemed successful, universities could use this program to assist other students who are studying algorithms, or have difficulty understanding the concept of them.

Another aim for this project that would be nice to achieve, other than to benefit the students learning process, is to increase the students' interest on this topic. Algorithms is one of my favourite topics I had came across as a computer science student during my course in university. By designing and developing this program, I hope to achieve the same sentiments in regards to my interest in algorithms to other students who are studying this topic as well.

1.3 Summary of research and analysis

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Chapter 2

Design

2.1 Description of the design

2.2 System requirements

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2.2.1 Functional requirements

Table 2.1: Functional requirements of the software

No.	Requirements	Description
Menu		
1	Shows the list of playable algorithms	In the menu, the program is to show all the algorithms available in the program in the main list. In this list, user can select whichever algorithm they wish to see.
2	Classify the available algorithms between the 3 main algorithmic paradigms	On the main list, the algorithms are to be classified between the 3 main paradigms, such as the greedy method, divide and conquer, and dynamic programming. This is to allow the users to understand immediately the correlation between similar algorithms when classified within its paradigms. This is also to increase the ease of usability, as users will only be required to look within the algorithms paradigm to search for a specific problem.
Animation		
3	Plays the animation	When the animation is in its initial or paused state, users can play the animation. This initiates the animation, which plays until the end, unless the user either pauses or stops the animation.
4	Pauses the animation	The user can pause the animation, which stops the animation temporarily at its current state.
5	Stops the animation	When the animation is playing, user can stop the animation. This ends the animation completely at any point of time during the playtime of the animation.
6	Backtracks the animation	During the animation's playtime, the program keeps track on the number of iteration(s) the animation is currently at. When a user chooses to backtrack the animation, the animation will <i>rewind</i> itself from its current iteration i , to $i - 1$.
7	Shows a short description during the animation on each <i>iteration</i> of the algorithm	During the animation's playtime, the program is to show a short description about what the animation is doing.

Table 2.2: Functional requirements of the software

No.	Requirements	Description
Help option		
8	Adjust the speed of the animation	Users can adjust the speed of the animation ranging from 1 (very slow), to 10 (very fast). By default, the speed of the animation will be set to 5.
9	Adjust the font size	Users can adjust the font size to fit their own requirements. Users can pick sizes from small (font size 8), default (font size 12), and large (font size 16). By default, the general size of the fonts in the program will be sized 12.
Additional features		
10	Suggests to play similar algorithms	When users view a certain algorithm, the program also suggests an algorithm alike with the currently viewed one. This is to enhance better learning experience for users to seek out on similar problems
11	Appendix that shows further writeup of the algorithms available in the program	This shows the full writeup of the description shown during the animation, and additional information in regards with the algorithm.

2.2.2 Non-functional requirements

Table 2.3: Non-functional requirements of the software

No.	Requirements	Description
Graphical interface		
1	The images for the animation is to be scalable depending on the size of the user's input	The physical size of the animation highly depends on the input size given by either the user or the random generator. Due to this, the program needs to carefully scale the animation when it is either too small or too big for the screen. It needs to ensure that the user can easily see the images and fonts of the animation, whether the input size is small or large.
2	Tables included in the animation demonstration are to be scrollable when it gets larger than a specified size given	Some algorithms require a table, especially the dynamic programming types. The table varies in size depending on the size of input for the algorithm. If the table width and length gets bigger than a specific size given, instead of exceeding the size, the program is to add a scrollable feature for the table.
3	The program is to be clear and easy enough for users to comprehend its design	The colour scheme of the program is to have a calming, non-blaring proposition. The images and fonts along with it needs to be shown clearly, and easily relatable for the general public.
Settings		
4	Saves the settings provided by user	The program is to save the changes made by user under settings. This means that when the user opens the program again, the changed settings will still be in placed.

Not sure if saved settings belong in non-function

2.3 UML case diagram

The use case diagram below on figure 2.1 is the representation of what the user can do to interact with the system represented in use cases. It is basically shows the relationship between the user and the system, for this case the student's interaction with the algorithm animation program.

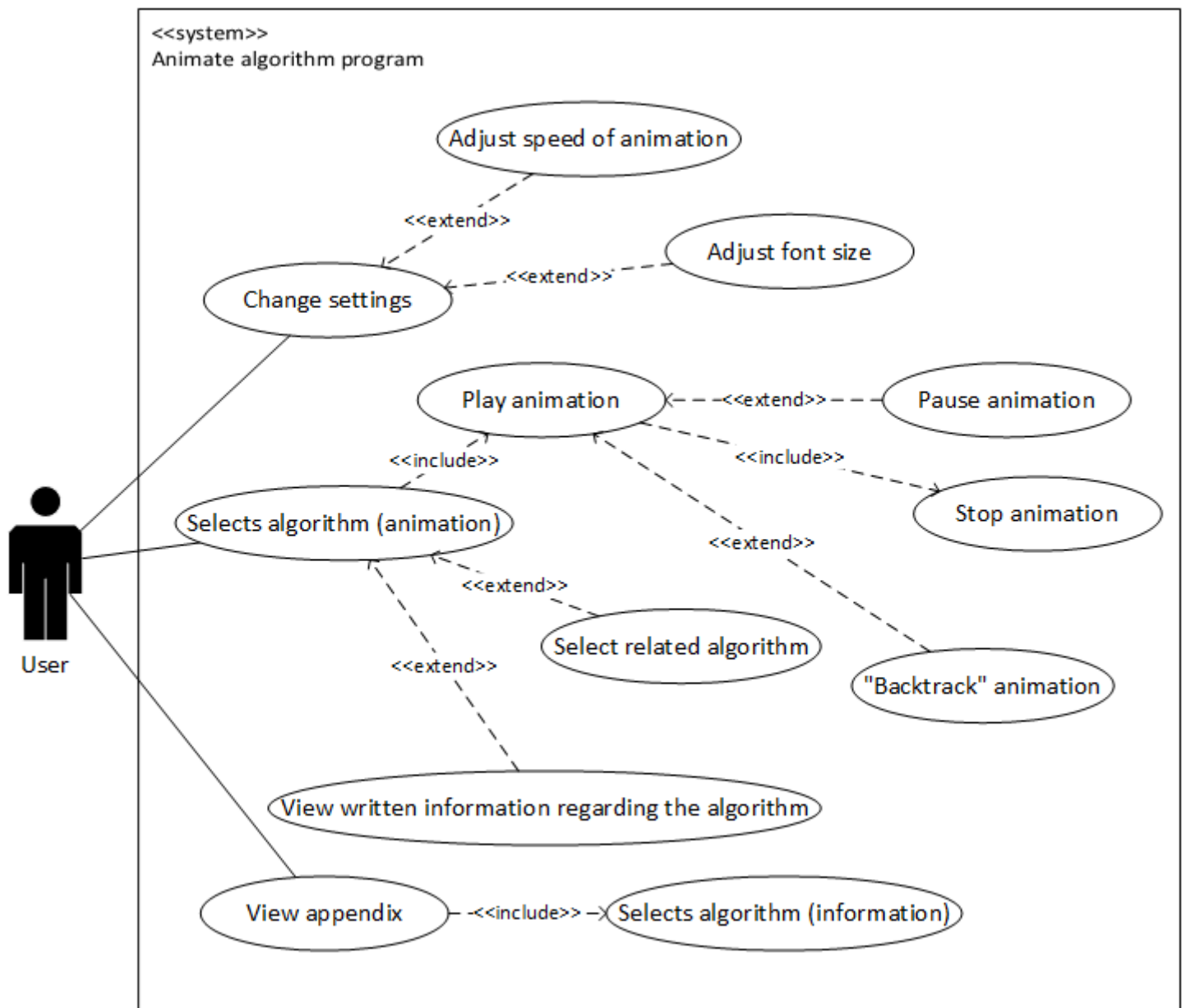


Figure 2.1: The system use case diagram

According to the use case diagram on figure 2.1, firstly, the user can change the settings in the program, by changing features such as the speed of the animation, or the font size displayed in the program. This allows the user to work within the environment that is most comfortable for them.

Other than changing the settings, the user can also select an algorithm which they wish to learn. This will lead them to the page where the animation of the algorithm is. From here, the user can manipulate the animation, by pressing controls such as play, pause, stop and "backtrack". For more information in regards to these controls, refer to the . From this page, the user can also access the algorithms which are *related* to the one in question, if they ever wish to do so. This will lead to the page of the algorithm along with its animation.

Other than the settings and the animated feature, if the user ever wishes to know more about the algorithms, the user can view them in the appendix within the program. In the appendix, the user will find all the algorithms available in the program in a list. Once the user selects a particular one they wish to see, the page will display a fuller information in regards to the algorithm. This includes the written up information, and might also involve a few images as well.

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2.4 System flowcharts

In this section, I have included the flowcharts of the program, to display the how the program flows in general, and how decisions controls its following events.

2.4.1 Main flow of the program

The flowchart below on figure 2.2 shows the overall flow of the program itself. The three main modules which makes up the program, i.e. change settings, view the animation of algorithms, and the appendix, are grouped in its respective subprocesses. Each subprocess will be described more in detail in sections 2.4.2, for the animation module, and ?? for the appendix module.

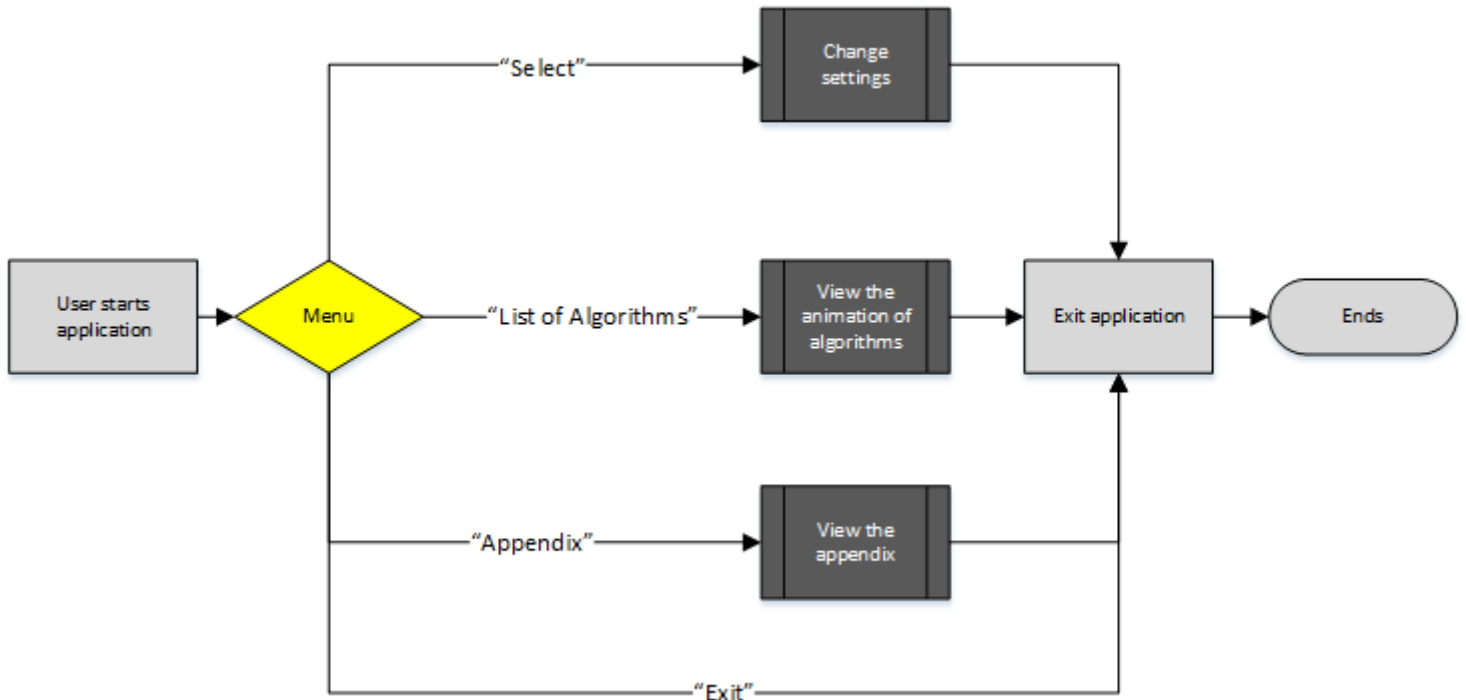


Figure 2.2: The flowchart of the whole system.

On the main flow chart below, the user first starts the application, which then brings them to the main menu. From the main menu, the user can select up to three features they wish to use, which are *Select*, *List of Algorithms*, and *Appendix*. Doing so will bring to the respective features. From the main menu, the user can also choose to exit from the main menu, by selecting *Exit* which then closes the whole application.

2.4.2 Flow of the animation module

The animation module is admittedly the main feature of the program that will be heavily concentrated during the course of the implementation of the project. The user first selects the *List of Algorithms* button, which then leads to the animation module. From here, there will be a list of the algorithms classified between 3 main paradigms and a sorting algorithm section. When a user selects an algorithm they wish to view, this will lead them to a page where the animation (in stopped mode), and the small description in regards to the algorithm.

The program will first prompt the user either to enter their own specific input, or the generate a random value instead. When the user decides to add their own input, there will be a specific limit assigned to the algorithm. If the input exceeds the limited amount, the program

will throw an error message to inform user that the input was unacceptable and requests the user to add an input that does not exceed the assigned limit. On the other hand, if the user selects to generate random value, the program will generate a random value within the limited amount assigned.

Once an input has been either retrieved or generated, the user then will be able to play the animation by pressing the play button. Whilst the animation is at its *playing state*, the user can control the animation by either *pause*, *backtrack*, or *stop* the animation. The state of the animation depends on what type of controls have been selected by the user, and below is a table 2.4, shows the outcome of the animation's state when a particular control button has been selected by the user.

Table 2.4: The list of animation controls.

Control	Description
Play	This button simply initiates the animation. Only available when the animation is either at its initial stage, <i>paused</i> , or <i>stopped</i> .
Pause	When a paused button is activated whilst the animation is playing, the animation stops temporarily. The stopped time will be saved, and will continue from that time if whenever the user chooses to play the animation. User can only pause the animation when the animation is being played.
Backtrack	This is a unique feature that comes in with the program. As the animation is animated through the use of <i>iterations</i> , these iteration values will be counted and stored programmatically. When a user clicks backtrack, the iteration counter, i , will be brought back to the previous iteration, which is $i - 1$. Once it goes back to its previous iteration, the animation will be brought to its <i>paused</i> state. From here, the user can press <i>play</i> , which will initiate the animation from that particular state.
Stops	A stopped button will completely halt the process of the animation. Its final playing state will be discarded once a stop button is selected.

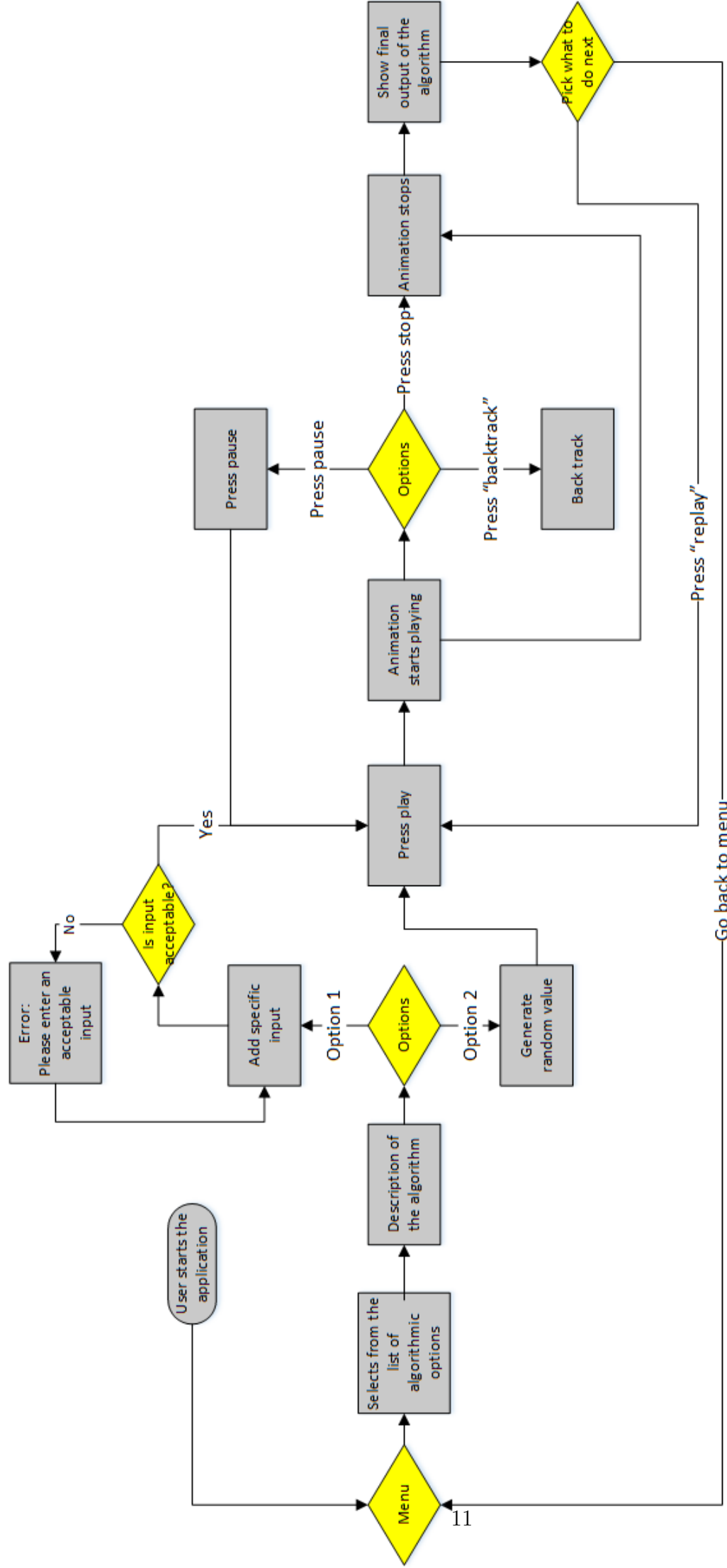


Figure 2.3: The flowchart of the animation module.

2.4.3 Flow of the appendix module

Finally, the last module would be the appendix module, which will contain the supplementary material in regards to the algorithms that are used in this program. This basically lists all the algorithms that are used, and users can select any algorithm within that list to view more information about the algorithm.

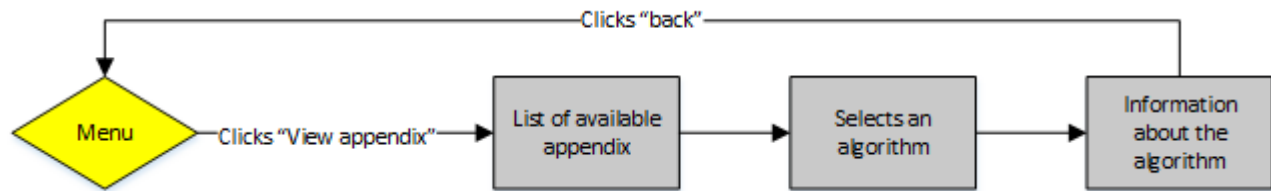


Figure 2.4: The flowchart of the appendix module.

The flowchart on figure 2.4 refers to the sequence of events that are involved within the module. First, from the main menu, as when the user selects *View appendix*, the program then brings the user to the list of all the available appendix found in the program. The user then could select the algorithm they wish to find out more about, by clicking into one. This will then lead the user to the page that predominantly presents the detailed information in regards to the algorithm in question.

2.5 Graphical User Interface design of the system

2.5.1 Program start page

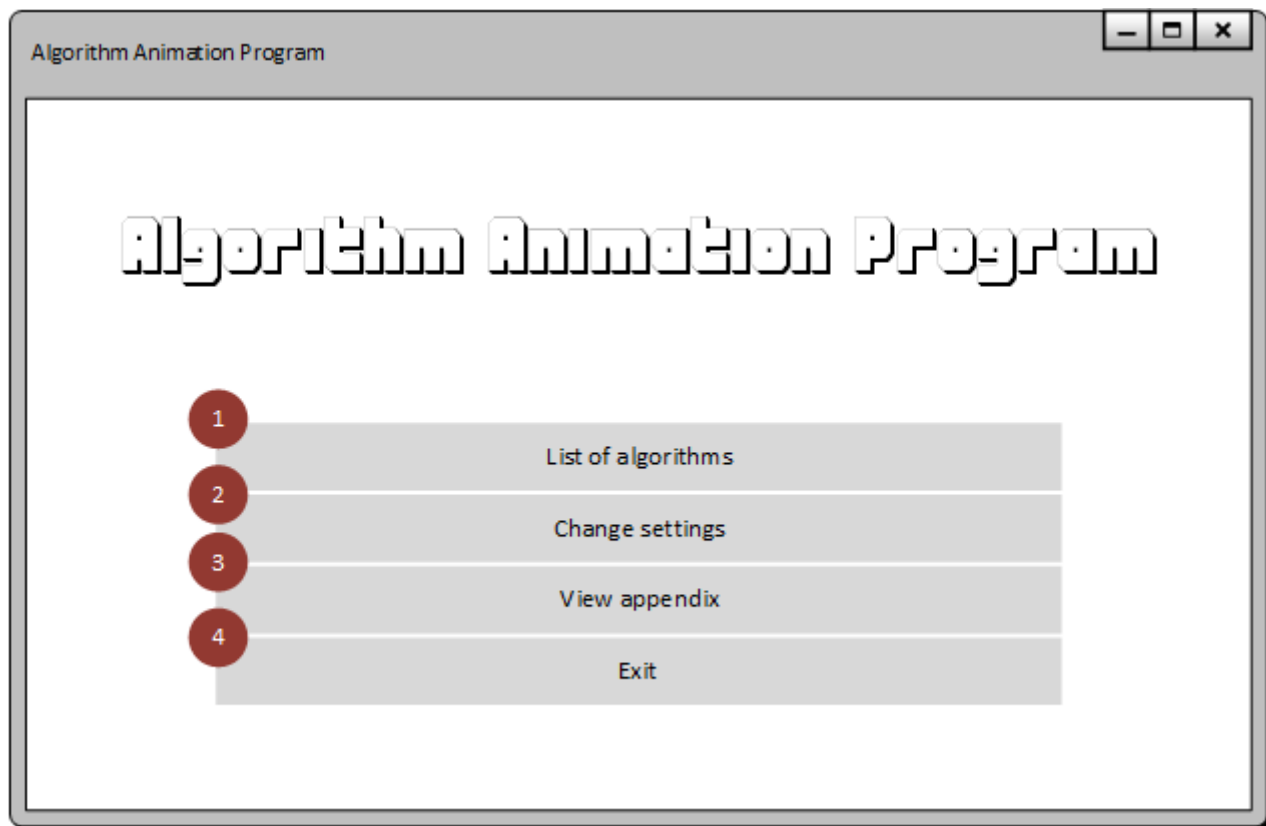


Figure 2.5: The start page of the program

As the program first initiates, the UI design shown in figure 2.5 will be the start page of the application. The start page displays the main menu of the application, which as mentioned earlier in sections ??.

1. The *List of Algorithm* button leads the user to the list of algorithms. In this list, user can select whatever algorithm they wish to learn. Refer to section ??, figure ?? for more details.
2. The *Change settings* button on the other hand, leads the user to a settings page.
3. The *View appendix* page brings the user to the main appendix list, which lists all the algorithms that is shown within the program.
4. Finally, the *Exit* button would close the whole application, if the user selects it.

2.5.2 Settings page

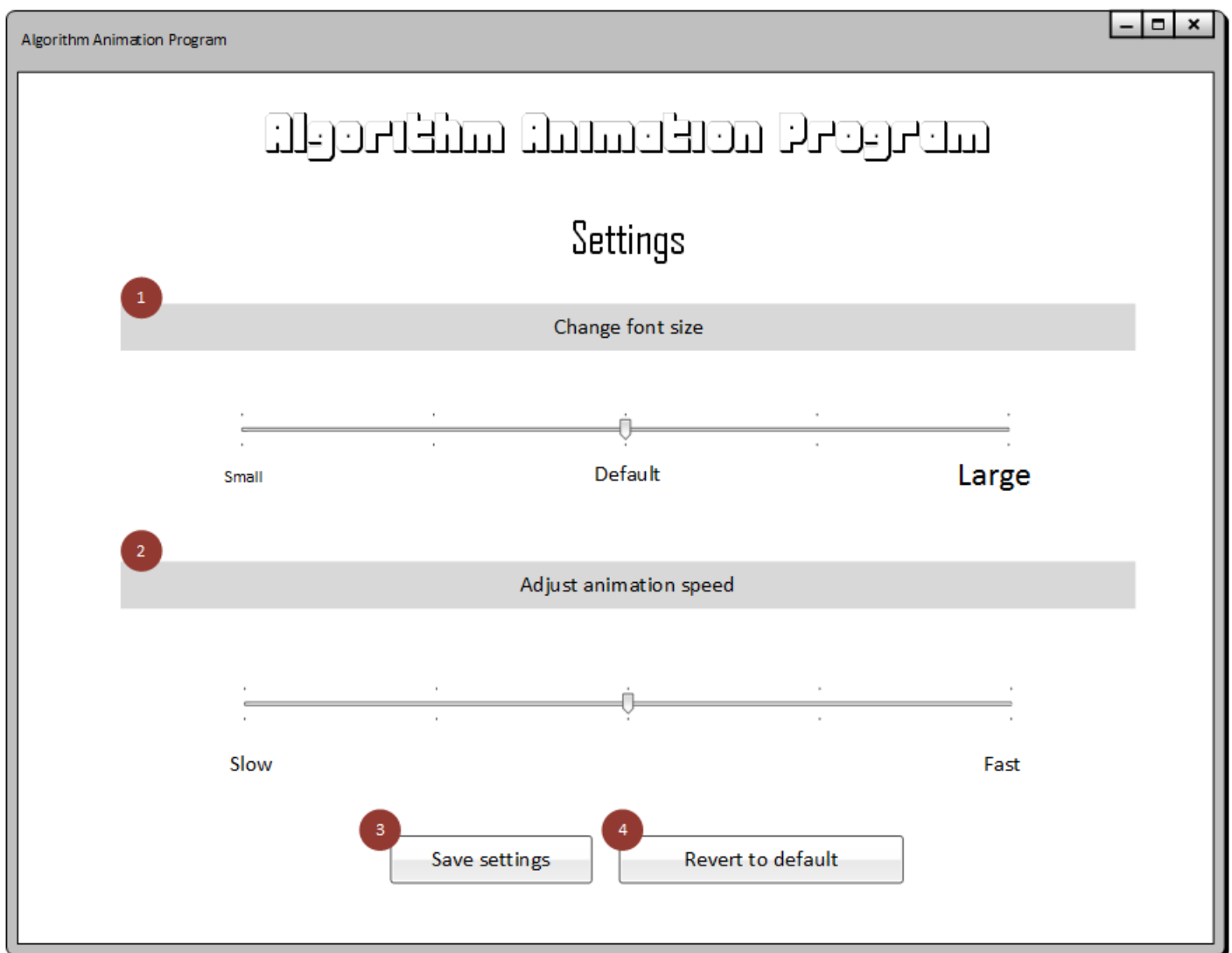


Figure 2.6: The settings page.

On the *Settings* page, users can adjust several features of the program, for this case, the font size, and the animation speed. The reason for having a settings page is to ensure that the users will have the ease in working in a comfortable environment.

1. One of the features the user can change is the font size. In order to change the font size, the user is to use the slider below. From the leftmost part of the slider is the smallest size of the font, which is size 9pt. The default size on the other hand is 12pt, followed by the largest possible size is 18pt. The user can adjust the font size from 9pt (smallest) to 18pt (biggest) by using the slider.
2. Secondly, the user can also change the animation speed. Initially, the animation will be running on a default speed of . However, if the speed is either too fast or slow for the user, the user could always adjust the speed by sliding to the leftmost bit of the slider for slower speed, and rightmost for a faster speed.

find the specific speed of the animation!

2.5.3 List of algorithms page



Figure 2.7: The page that shows the list of algorithms available for animation.

In this page basically shows the list of all the algorithms that are available in animation. These algorithms are also to be classified between the three main algorithmic paradigms, which are *greedy method*, *divide and conquer*, and *dynamic programming* approaches. Also, another classification would be the sorting algorithms will be included in the list as well.

1. Shows the list of all the algorithms available. These algorithms are also classified according to its respective algorithmic paradigms. Users can click any of those algorithms displayed in that list if they wish to learn more about them.

2.5.4 The page of the animation of the algorithm selected

Algorithm Animation Program

Algorithm Animation Program

1 Heap Sort

2 Enter the number of elements of the array

Enter the values for each element of the array

8

11

6

1

8k

3

4

7

12

Value is not numerical

4 [Generate random values instead!](#)

5 Submit

6 Back

Are you sure?

7 ! You are about to submit your values. Are you sure?

No, make further changes

Yes, proceed

Figure 2.8: The page that shows requests the input from the user before starting the animation of the algorithm.

1. The title of the algorithm in question.
2. The form page of the list of input that is required for the heap sort animation.
3. As all fields are equipped with validation, it will throw an error message in regards to the field if it happens to receive the wrong input. For this case, the user fails to insert a numerical value.
4. Another option instead of adding the user's own input is to generate random values for the animation.
5. This button submits the values and proceeds to the next page, shown in figure 2.9.
6. This button simply brings the user back to the list of algorithms.
7. This dialog will be prompted once the user clicks the *Submit* button. This is to ensure that the user is happy with the input they have given. From here, if they click *No, make further changes*, the dialog will close, and the page remains the same. If the user clicks *Yes, proceed*, the program will proceed to the next page, which is shown in figure 2.9.

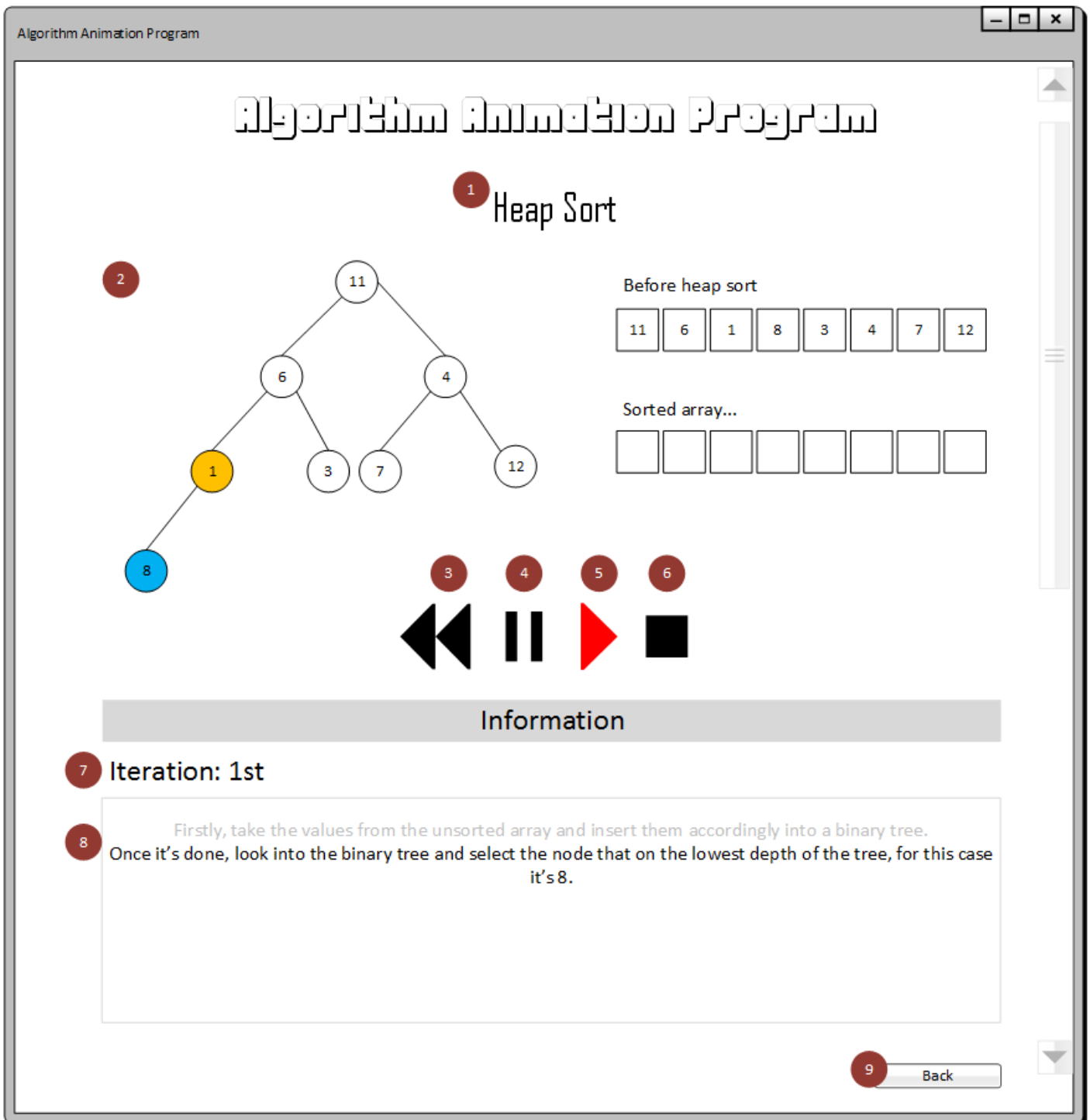


Figure 2.9: The page that shows the animation of the algorithm.

1. The title of the algorithm in question.
2. The section of the page where the animation of the algorithm is carried out.
3. The backtrack button.
4. The pause button.
5. The play button. Turns red when the animation is at the *playing state*. This applies to other control buttons as well.
6. The stop button.

7. The number of iteration the animation is currently at. Every time the animation finishes its *main loop*, the iteration counter is added, and it will be displayed here.
8. The area where a written information regarding the animation is displayed. Every time an animation displays something new, a new text block is displayed here, along with the numbers (variables) involved the animation. Once the animation has moved on to the next step, the text mentioned will be greyed out, as the new text will be the one that is emphasized.
9. The button simply brings the user back to the previous page which would be the main list of algorithms. Whatever that is played in the animation will be discarded.

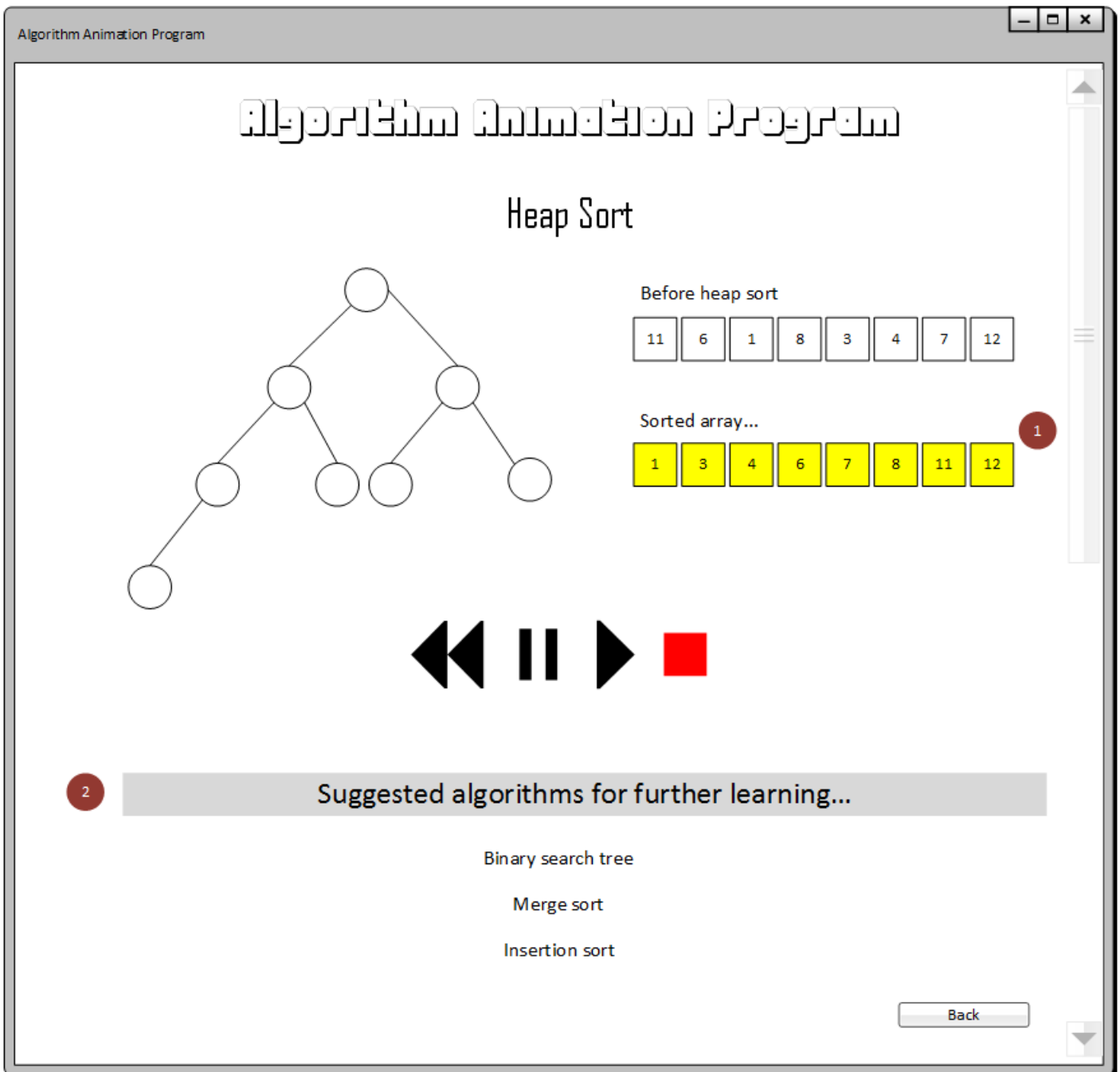


Figure 2.10: The page's layout when the animation has finished playing.

1. The animation stops right when the array has been fully sorted (only applies in sorting algorithms), or in general, has satisfied its respective goal(s). For this example, the sorted array is highlighted in yellow to show that the values in the array has been fully sorted.
2. Secondly, once the animation has ended, it also suggests the user on algorithms that are closely related to the current one for a comprehensive learning experience.

2.5.5 The appendix page

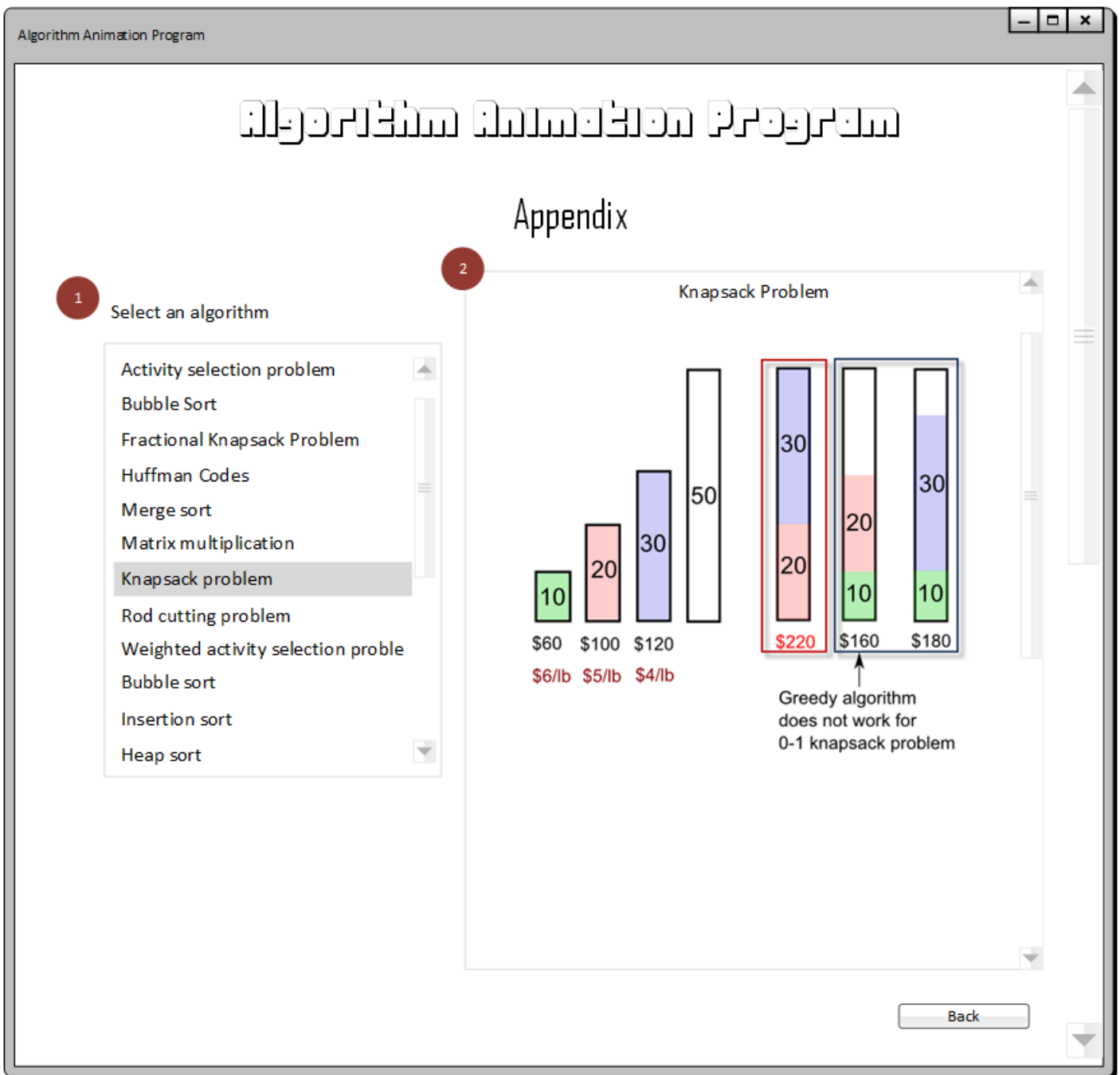


Figure 2.11: The appendix page which lists the algorithms available in the program, which then shows further information regarding the algorithm.

1. This section lists all the algorithms available in the program.
2. This section on the other hand displays whatever information about the algorithm selected from the list in no. 1.

2.6 UML class diagram

2.7 UML Sequence Diagram

2.7.1 The animation feature

The sequence diagram shown in figure 2.12 shows the interaction between the user and the different objects involved within the animation module found in the program. First and foremost, as the user initiates the program, the program will display the main menu by executing the *displayMenu()* method. From there, the user selects (for this case) the *List of algorithms* button, which leads the user to the main list of algorithms.

The user then can pick any algorithm they wish to learn from this list. For example, the user decides to learn how the merge sort algorithm works. So the user clicks the button called *Merge sort algorithm*, which then leads the user to the next page, the input request page, or known as *AlgorithmAnimationInputRequest* according to the sequence diagram in figure 2.12.

Once the values have been inserted, the program proceeds to the animation page by calling out the *displayAnimation()* method, along with the *play()* method that plays the animation. Once the animation is playing, the user can manipulate the animation by using the control buttons such as the *play*, *pause*, *stop*, and *backtrack* button. Each of these controls has its own call of method, and will be called accordingly depending on which control button is pressed.

If any control button is pressed, the program then calls out the *displayAnimationRealTime()* method. This method is predominantly used to run the animations, such as keeping track of the iteration(s) of where the animation is currently at, and also tracks where the timing of the animation is currently at when a control button is clicked. Of course, the latter does not apply to the *stop* button, as the animation will be told to immediately reach to the end once the animation has stopped.

Once the animation has stopped, either by the user or the animation simply reaches to its own end, the program will then give the user an option of viewing other algorithms that are similar to the one in question, by calling the *getSuggestedAlgorithms()* method. The user can either click one of the suggested algorithms, or choose to go back, which brings them to the main algorithm list.

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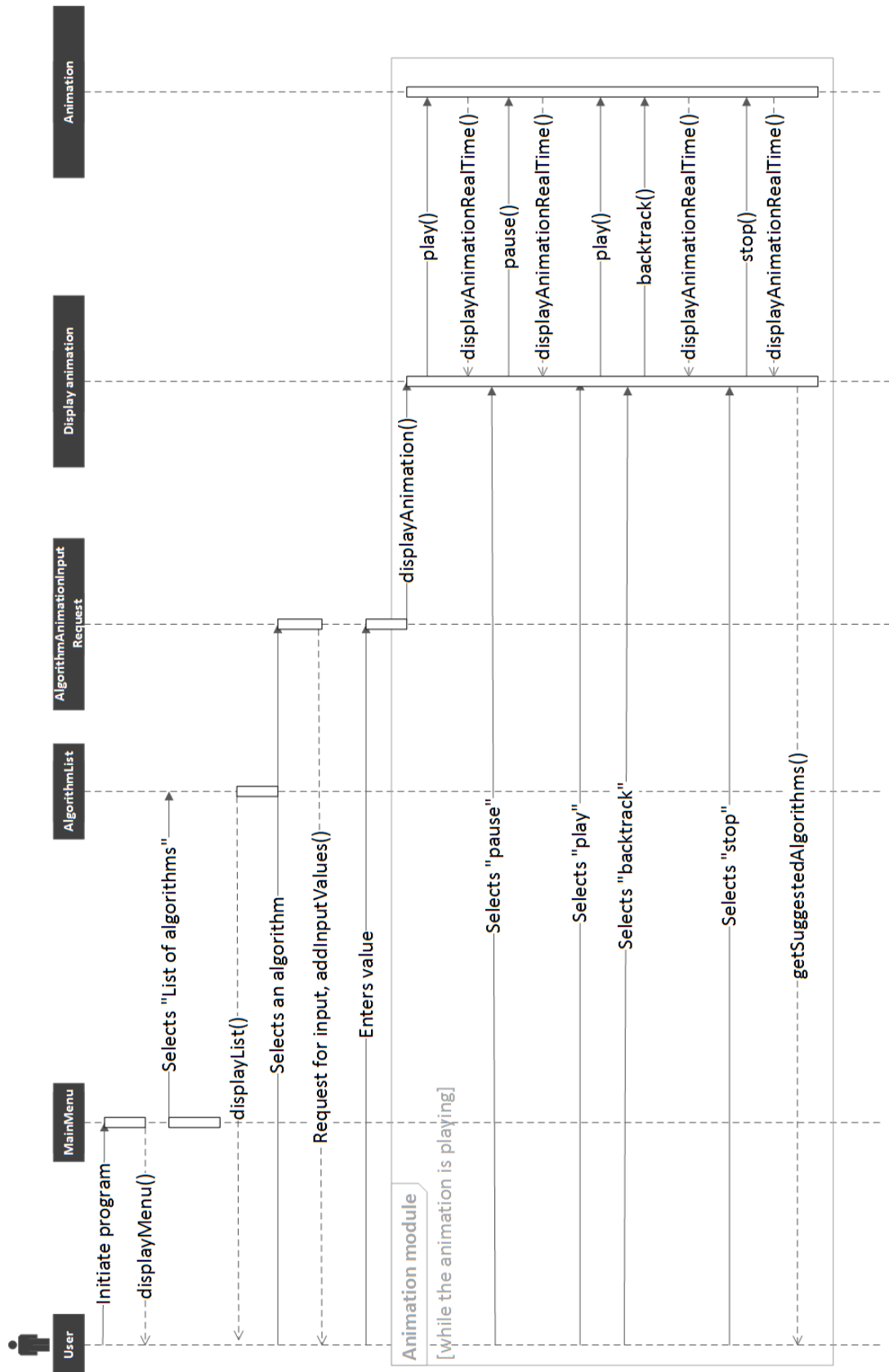


Figure 2.12: The sequence diagram of when the user uses the animation feature.

2.7.2 The settings feature

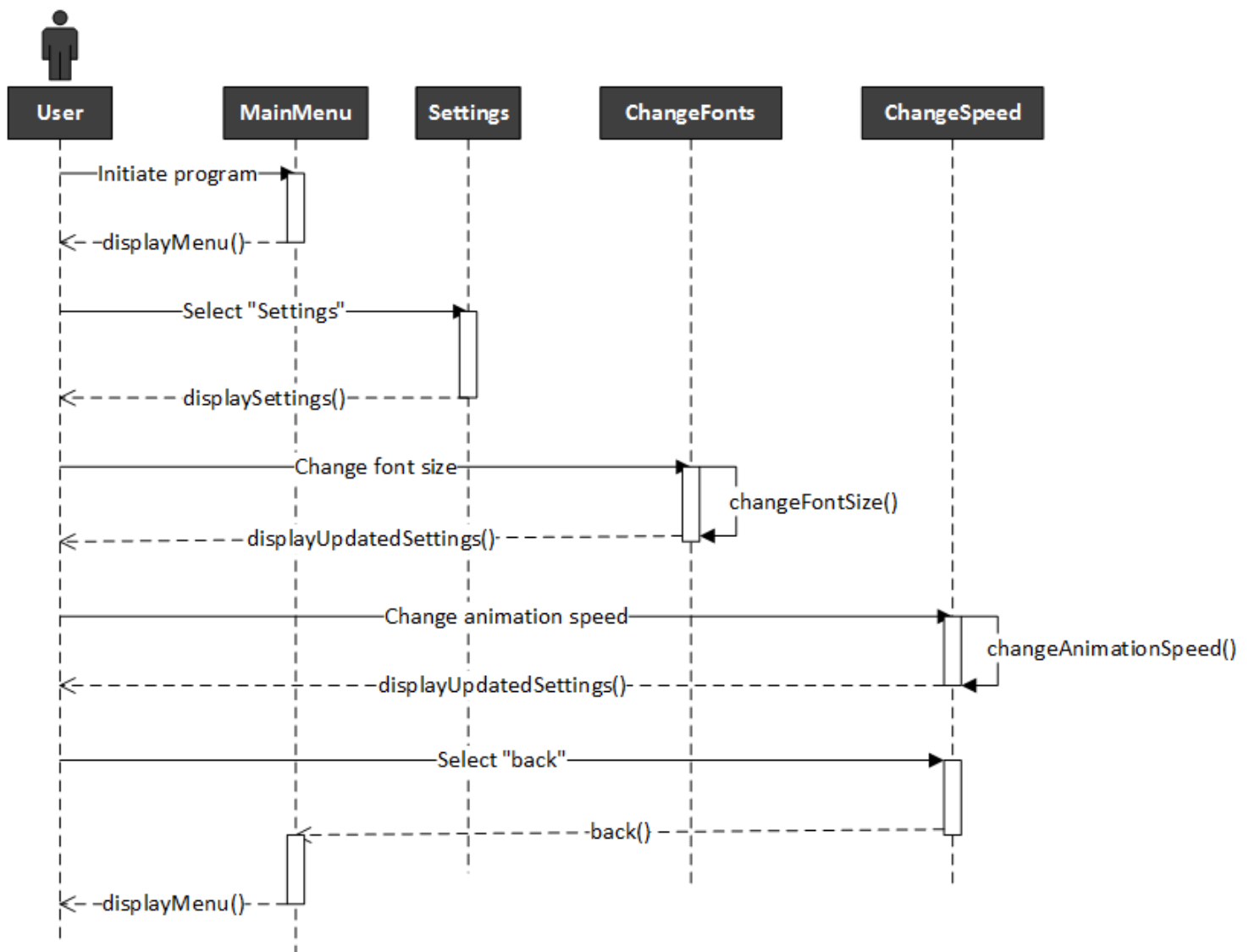


Figure 2.13: The sequence diagram of when the user uses the settings feature.

Another feature that is available in the program would be the settings feature. Based on the sequence diagram in figure 2.13, when the user opens the program, the program will call the `displayMenu()` method to display the main menu onto the client. For this case, the user then selects *Settings* button, which leads them to the settings page, called out by the `displaySettings()` method.

In the settings page, the user can change features such as the font size and the animation speed. When the user decides to change the font size by using the drag controller, the `changeFontSize()` method is being called out, with the current value depending on where the selector along the slider. Once that is done, the program then calls out the `displayUpdatedSettings()` to change the outlook of the program to whatever that is changed. The same applies to when the speed of animation is changed, however this time, the `changeAnimationSpeed()` method is called out instead.

Once the user is done with changing the settings, they could press the *Back* button, which leads them back to the main menu. To see the graphical interface design of the settings page, do refer to figure 2.6, on page 14.

2.7.3 The appendix feature

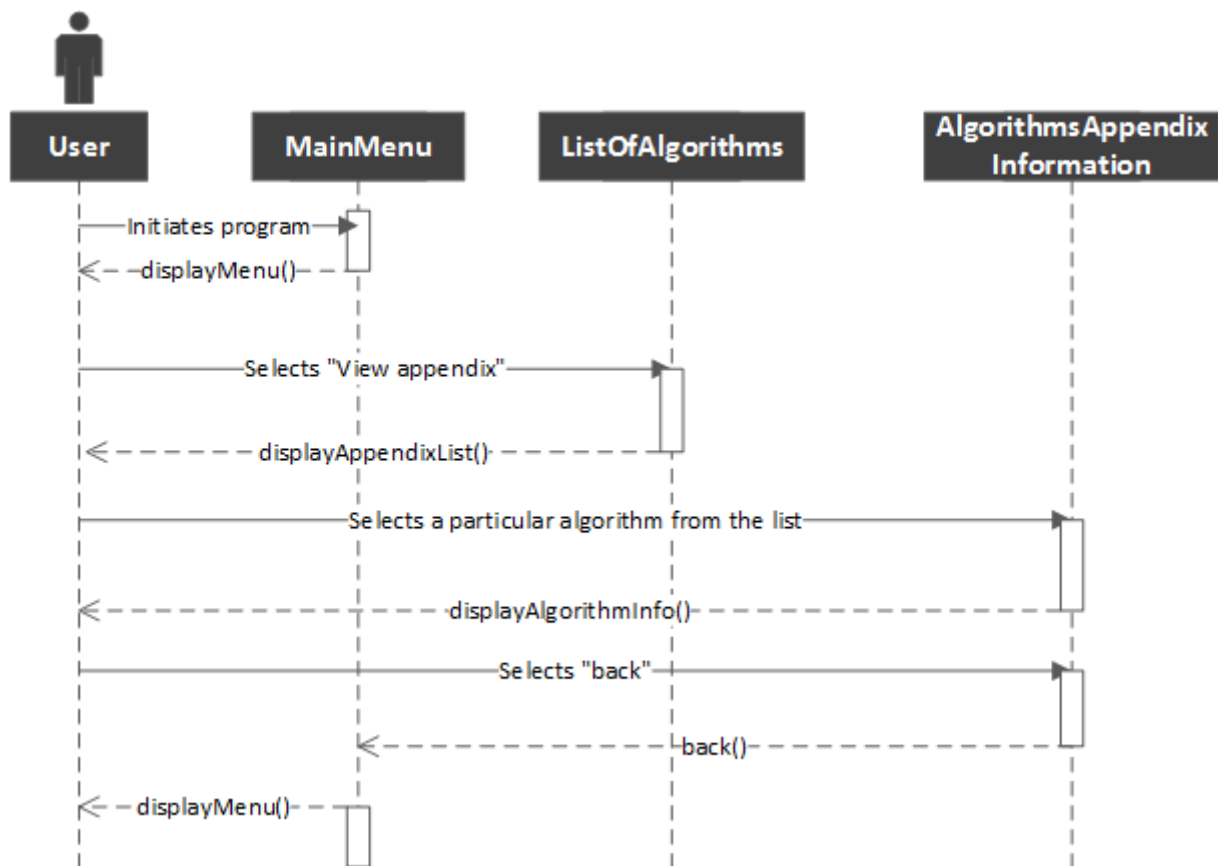


Figure 2.14: The sequence diagram of when the user uses the appendix feature.

Last but not least, the appendix would be the other feature that would be available in the *Algorithm Animation* program. As per usual, as when the user initiates the program, the user would be led to the main menu. Once there, the user then clicks the *View appendix* button, which calls out the `displayAppendixList()` method, and leads the user to the appendix page.

Once the appendix page has been displayed, the user then can select the algorithm they wish to find out more about, within the list presented on the page. Once the user clicks one, the program calls out the `displayAlgorithmInfo()` with the name of the algorithm as the passing parameter, which displays the information available for the algorithm.

When the user is done, the *Back* button can be selected, which leads them back to the main menu. If you wish to refer to the graphical user interface design of the appendix page, refer to figure 2.11 in page 20.

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Todo list

Do this	3
description of anticipated components of the system and how are they organised	4
add small description	4
Not sure if saved settings belong in non-functional	7
add some glossary or some sort	8
find the specific speed of the animation!	14
brief description about sequence diagram	21
I left it off here	24