



UNIVERSITY OF LIVERPOOL

COMPUTER SCIENCE WITH A YEAR IN INDUSTRY BSc (HONS)

G403

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# 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. 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. In this project, the scope will revolve around the animations within the three main algorithmic paradigms, such as the greedy method, divide and conquer, and dynamic programming. And of course, some of the sorting algorithms will be included as well, as these types of algorithms are essential for those who has just started out in this area.

The primary purpose of this project is to develop a software that displays animations which shows how different types of algorithms within the 3 main paradigms and sorting works in general. From the program, the users are able to pick the algorithmic solution they wish to learn, either by entering a certain amount of input, or let the program generate random values instead. After the input has been provided, the student then would learn the workings of the algorithm 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 to be easily understood. To achieve such feat, there would be a need to use animations, which acts as a visual aid for the students to learn the algorithms from a different perception. As a computer science student myself, I believe that using visual tools such as the animations, would certainly enhance the students' learning experience. Doing so would also allow students to learn new algorithmic problems with convenience and ease.

It is generally known that algorithms is one of the more challenging topics within the computer science field, and is difficult for students to grasp at times. In this case, another aim for this project is to make this software as an additional tool, that could be used outside lecture periods, and assist students to achieve greater understanding in algorithmic paradigms. To achieve this, the program is to provide a comprehensive animated explanation of the algorithms in a step by step basis. 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.

One of my intentions for this project is to serve this software as foundation. From here, other developers who could use this as a platform, and populate the existing list by many other algorithms and its animations. If the project is deemed successful, the university could use this software on assisting the computer science students in regards to this topic.

## 1.3 Summary of research and analysis

During the design phase, I have made some research on the algorithms that I found feasible to apply in this project, with the time that I was given before completion. The algorithms I have chosen are also the ones that I have understood quite intensively, and that I am confident in applying these algorithms in code during the implementation stage. My only concern when it comes to this project, other than the amount of work that I have proposed in the design documentation, is the implementation of the algorithms into animations. Fortunately, after much research in regards of *C#* and with the help with Microsoft Visual Studio Blend 2015, I believe that I will be able to reach the goal in interpreting my knowledge in algorithms into animations.

On another note, the design documentation mainly consists of the structure of the program, such as its graphical interface, what are the components that will be included, and generally what is expected overall from the *Algorithm Animation Program*. Whatever research and plans that I have conducted during the design specification are all documented here. Of course, if everything goes well, these plans will be carried forward towards the implementation phase, where the components are finally put into place and put into actual use.

# Chapter 2

## Design

In this design chapter primarily consists of the plan for the construction of the *Algorithm Animation Program*. This design documentation includes the list of requirements that is expected of the program, the different uses of the program from the users' perspective, system flowchart, the graphical user interface design, sequence diagrams, the design of the animations for each algorithms, and finally the evaluation list.

### 2.1 Brief description of the anticipated software

The program initiates by displaying the main menu. From here, the users can select whichever category they wish to use. These categories include the two main different features of the program, which are *settings* and the *animation* feature.

With the *settings* feature, the user can change some of the aspects of the program, which are its font size and the speed of animation. Doing so would allow the users to work on an environment that feels most comfortable for them.

The animation feature on the other hand, which admittedly would be the main aspect of this project, where the list of different algorithms can be selected from. From here, the user selects the algorithm they wish to see the animation of. Once they have selected one, the program would proceed to the input page, where the form is. The user should either enter the required input in this form, or generate random values for them instead. It is worth noting that this form has a different structure depending on the algorithm, since different algorithms have varying sets of input. The user can either enter their own input (these input will be bounded with a specific limit), or generates random values instead.

Once the input page is filled with necessary values, the program proceeds to the animation page, where the animation starts playing from. The anticipated program will also have *controls* for the animation as well, such as the *play*, *pause*, *stop*, and *backtrack* buttons. Each of these controls are described further in depth within this design chapter.

#### 2.1.1 Functional requirements

The functional requirements of the *Algorithm Animation* program is to specify the list of requirements, that defines the system's behaviour and functionality of what the system needs to do. The tables below (tables 2.1 and 2.2) shows the list of functional requirements that is expected for the program to achieve, along with their respective descriptions.

Table 2.1: Functional requirements of the software

No.	Requirements	Description
<b>Menu</b>		
1	The main menu	The main menu is to list the selection of features for the user to select from.
2	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 the feature they wish to choose, such as the settings or the animation feature.
3	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 and the sorting algorithms. This is to allow the users to understand immediately the correlation between similar algorithms when classified within its paradigms. Also, the purpose of classifying the algorithms is to increase the ease of usability, as users will only be required to look within the algorithms paradigm in order to search for a specific problem.
<b>Animation</b>		
4	Plays the animation	When the animation is in its initial or paused state, users can play the animation. This initiates the animation, that plays it until the end, unless the user either pauses or stops it.
5	Pauses the animation	The user can pause the animation, which stops the animation temporarily at its current state.
6	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.
7	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 $i - 1$ .
8	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
<b>Help option</b>		
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.
<b>Additional features</b>		
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

### 2.1.2 Non-functional requirements

On the other hand, the non-functional requirements, refer to the set of requirements that describes how the system works in general, in terms of its operations. Table 2.3 below shows the set of non-functional requirements the system is expected to satisfy, along with its individual descriptions.

Table 2.3: Non-functional requirements of the software

No.	Requirements	Description
<b>Graphical interface</b>		
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 neutral, non-blaring overlay. The images and fonts along with it needs to be shown clearly, and easily relatable for the general public.
<b>Settings</b>		
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.



## 2.2 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 *Animated Algorithm Program*.

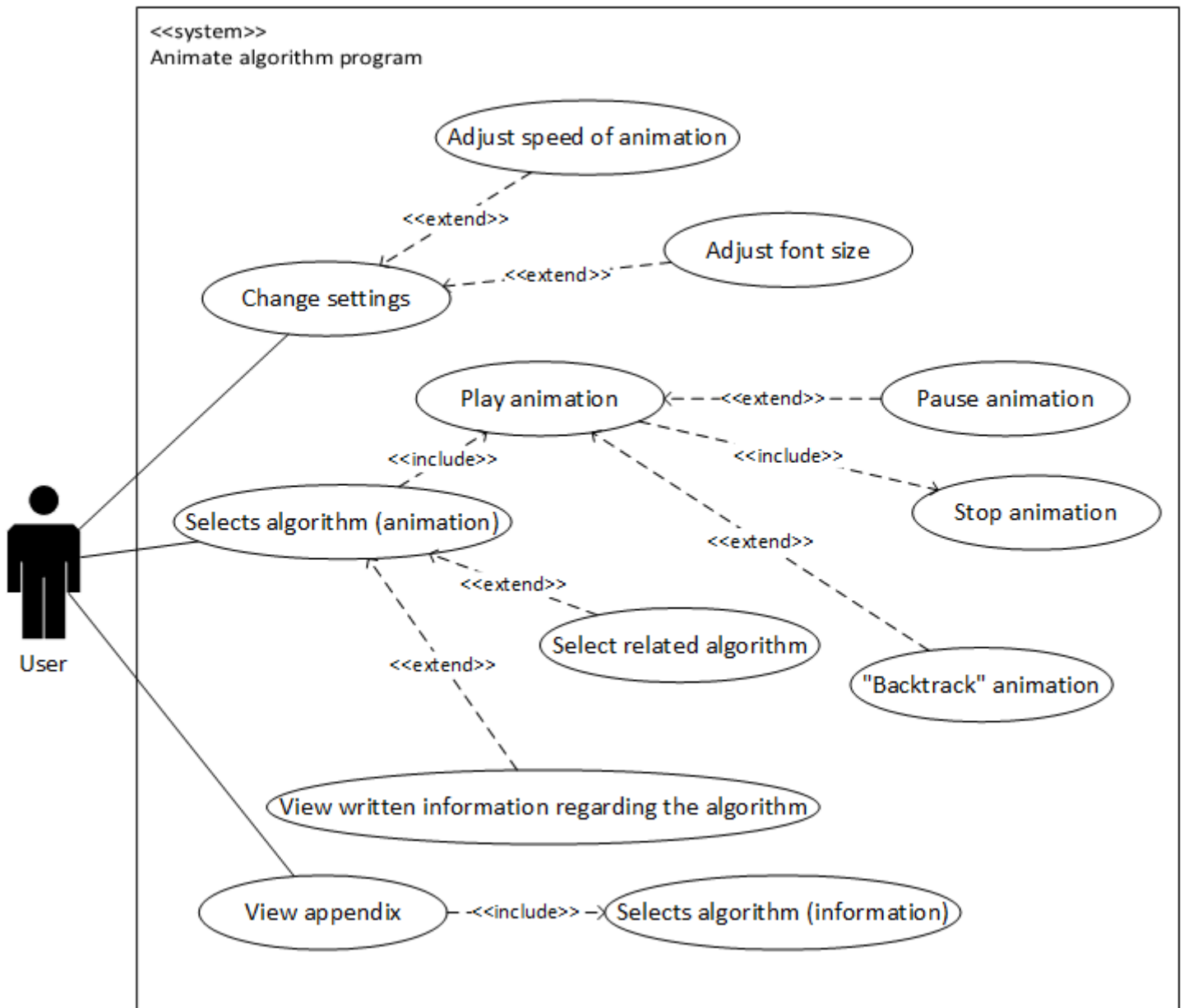


Figure 2.1: The system use case diagram

According to the use case diagram shown on figure 2.1, the user can change the settings of some of the features of the program, such as the speed of the animation, and its font size. This is to ensure that the user will be able to work comfortably within the environment, when the program allows the them to change these features of the program. The user could always revert back to the system's default settings if there is a need to.

Other than the settings, the animation is another feature that would be included within the program. By selecting an algorithm from the list of algorithms, the program will lead the user to the page where the animation of the algorithm resides in. From here, the user can manipulate the animation, by pressing controls such as play, pause, stop and "backtrack". The user can also access other algorithms that are *related* to the current one, if they ever wish to

do so. If the user clicks on the algorithm from the list of related algorithms, the program then goes to the animation page of the algorithm that was selected by the user.

## 2.3 System flowcharts

In this section, I have included the flowcharts of the program, that displays the flow of the system in general, and how decisions controls its following events.

### 2.3.1 Main flow of the program

The flowchart below on figure 2.2 shows the overall flow of the program itself. The two main features (settings and animation) are grouped within its respective subprocesses. Each subprocess will be described more in detail in sections 2.3.2 for the animation feature, and section ?? for the settings feature.

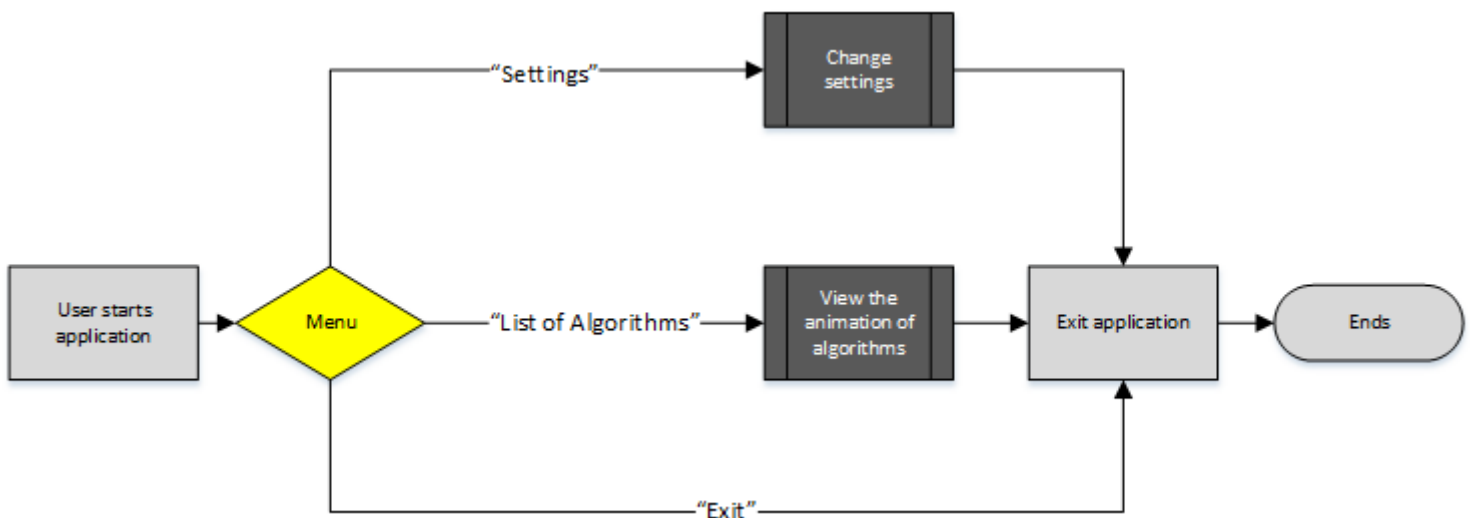


Figure 2.2: The flowchart of the whole system.

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

### 2.3.2 Flow of the animation module

The animation module is admittedly the main feature of the program which will be heavily concentrated during the course of the implementation of the project. The user first selects the *List of Algorithms* button, that leads to the animation module. From here, a list of the algorithms are classified between 3 main paradigms and a sorting algorithm into different sections for user feasibility purpose. When the user selects an algorithm they wish to learn more about, the program would lead them to a page where the animation is, and a brief description about the algorithm shown in the *Information* section placed below the animation.

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 the *Generate random value* button instead, the program would then generate a random value within the limited amount assigned, and input those values into the animation.

Once an input has been either retrieved, 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 the type of controls that have been selected by the user. To view the description of each control available in the animation page, below is table 2.4 that 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. This button is only available for use 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 this button, 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.

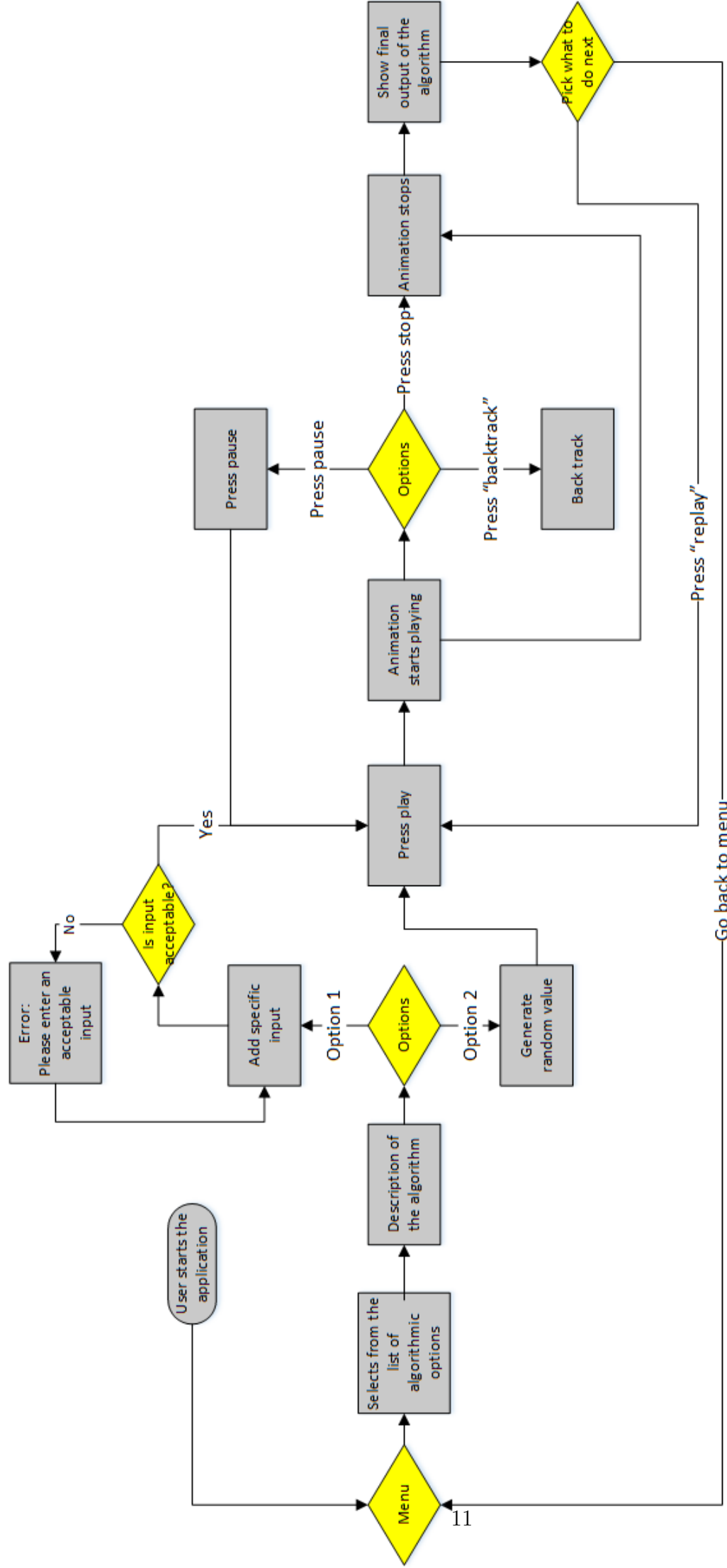


Figure 2.3: The flowchart of the animation feature.

### 2.3.3 Flow of the settings feature

The settings feature on the other hand involve in two options, the user can either change the font size, the animation speed, or both. Once the user has made changes, the program conduct those changes accordingly. Afterwards, the user will proceed back to the main menu.

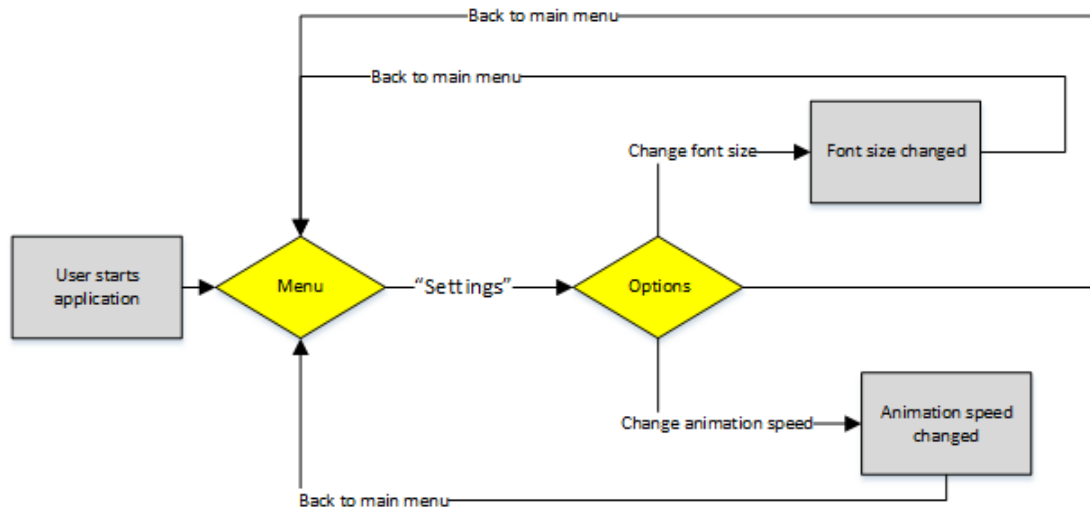


Figure 2.4: The flowchart of the settings feature.

## 2.4 Graphical User Interface design of the system

### 2.4.1 Program start page

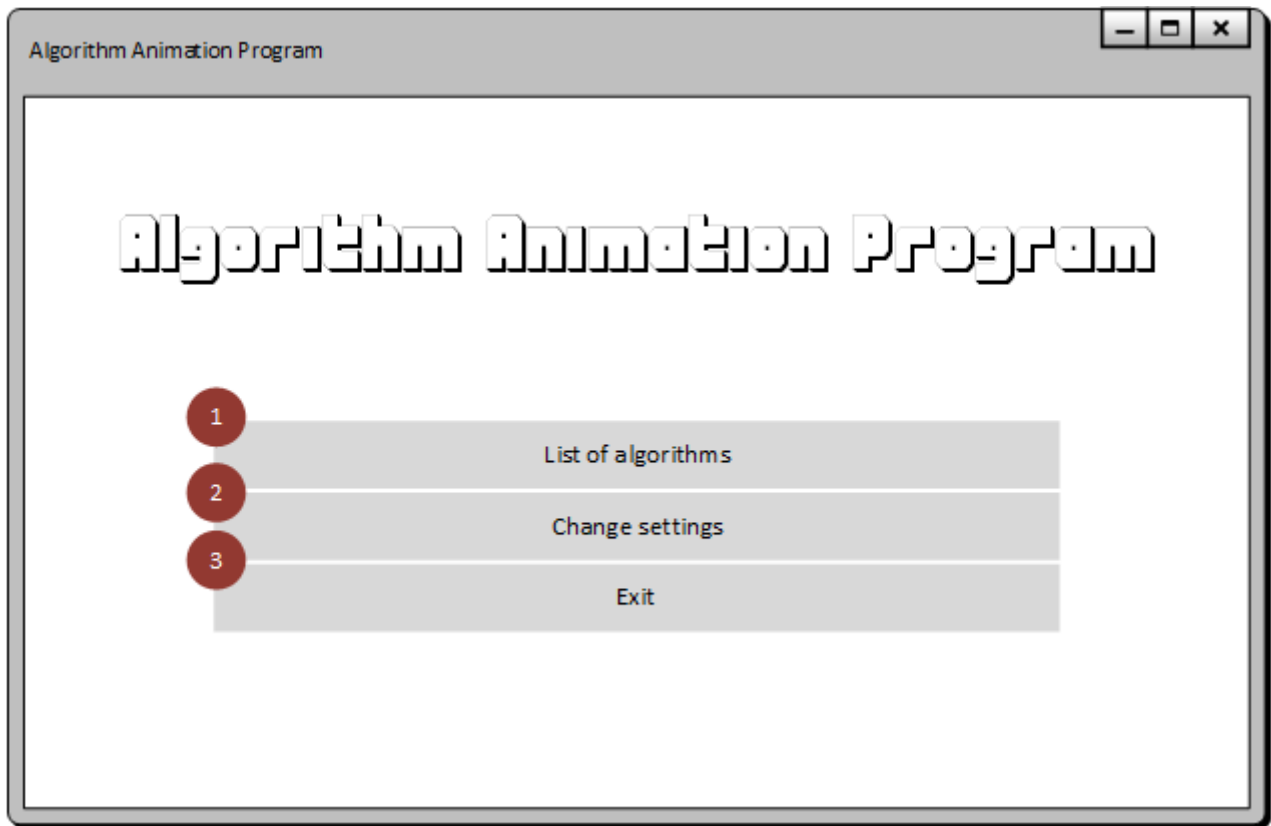


Figure 2.5: The start page of the program

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.

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.
2. The *Change settings* button on the other hand, leads the user to a settings page.
3. Finally, the *Exit* button would close the whole application, if the user selects it.

## 2.4.2 Settings page

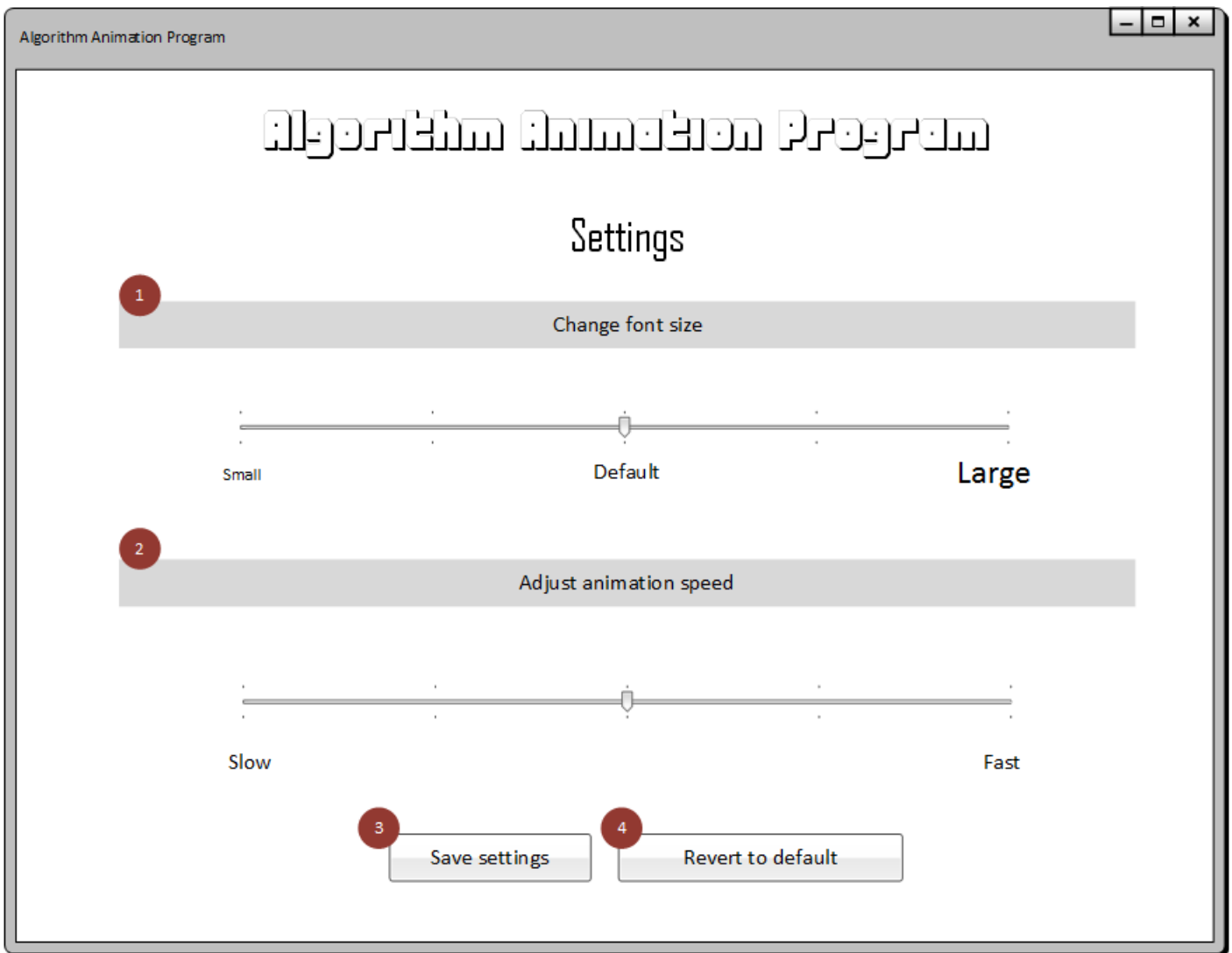


Figure 2.6: The settings page.

On the *Settings* page, users can adjust several features of the program, such as the font size, and the animation speed. The reason for having a settings page is to ensure that the users are working in an environment that they are most comfortable in.

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 8pt. The default size on the other hand is 12pt, followed by the largest possible size is 16pt.
2. Secondly, the user can also change the animation speed. The speed can be adjusted by sliding to the leftmost bit of the slider for slower speed, and rightmost for a faster speed.

### 2.4.3 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, as well as the sorting algorithms.

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.



#### 2.4.4 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

Value is not numerical 3

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.

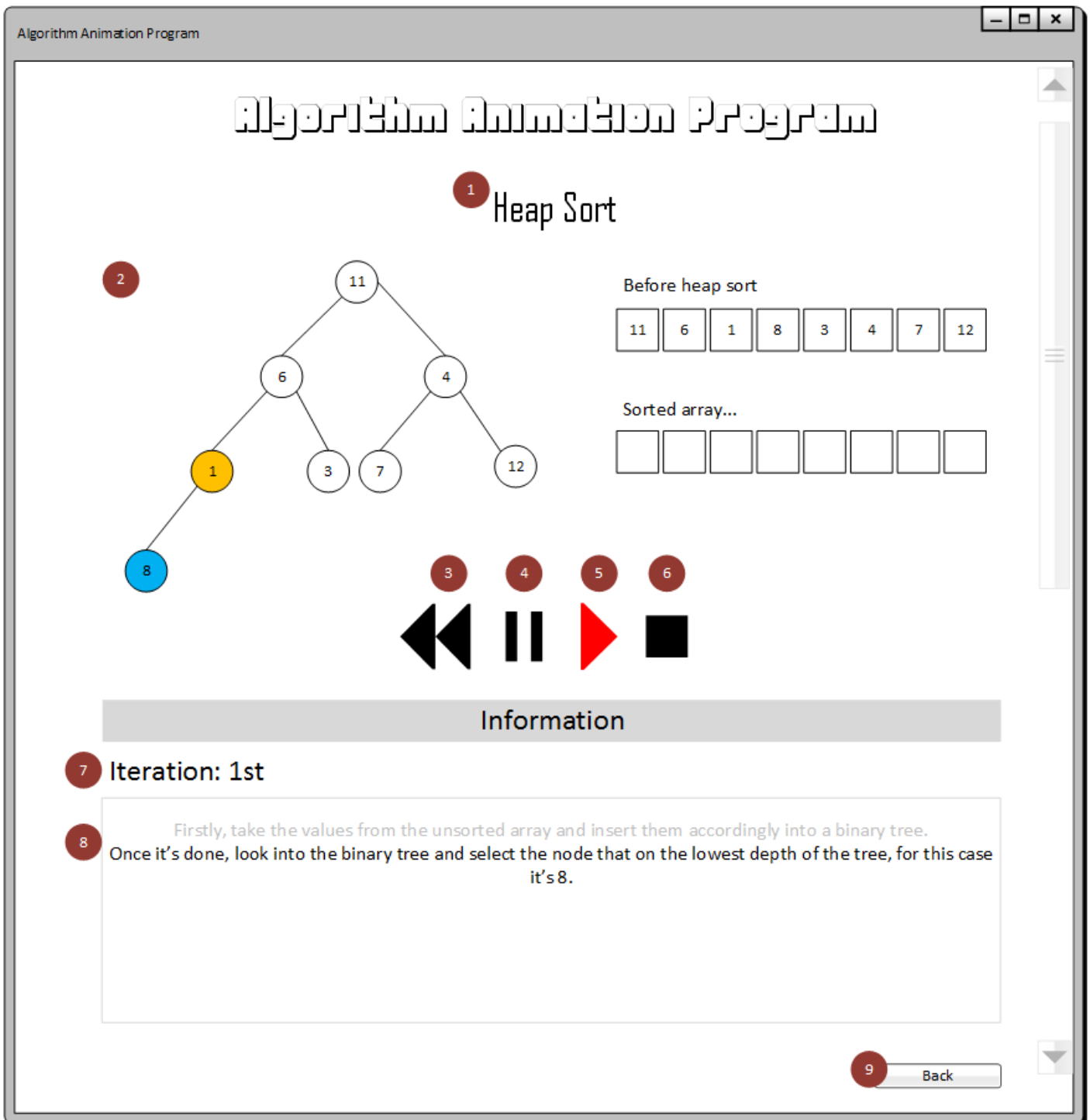


Figure 2.9: The page that shows the animation of the algorithm.

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.

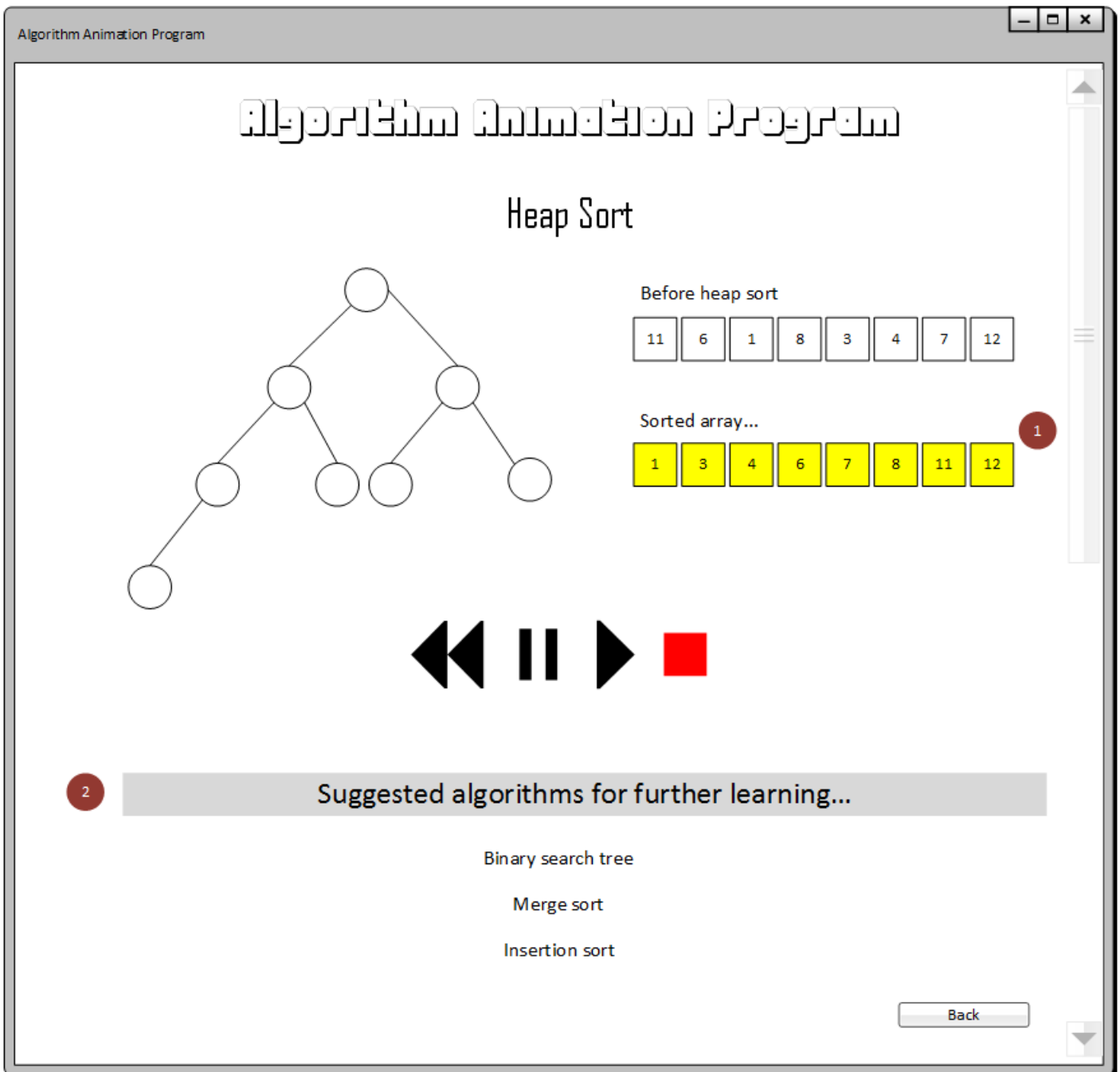


Figure 2.10: The page's layout when the animation has finished playing.

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 UML class diagram

Show in figure 2.11 is the class diagram of the *Algorithm Animation Program*. The class diagram is a representation of the objects, its attributes, methods, and their relationship amongst others. Whatever is shown in the class diagram will be involved in the construction of the system.

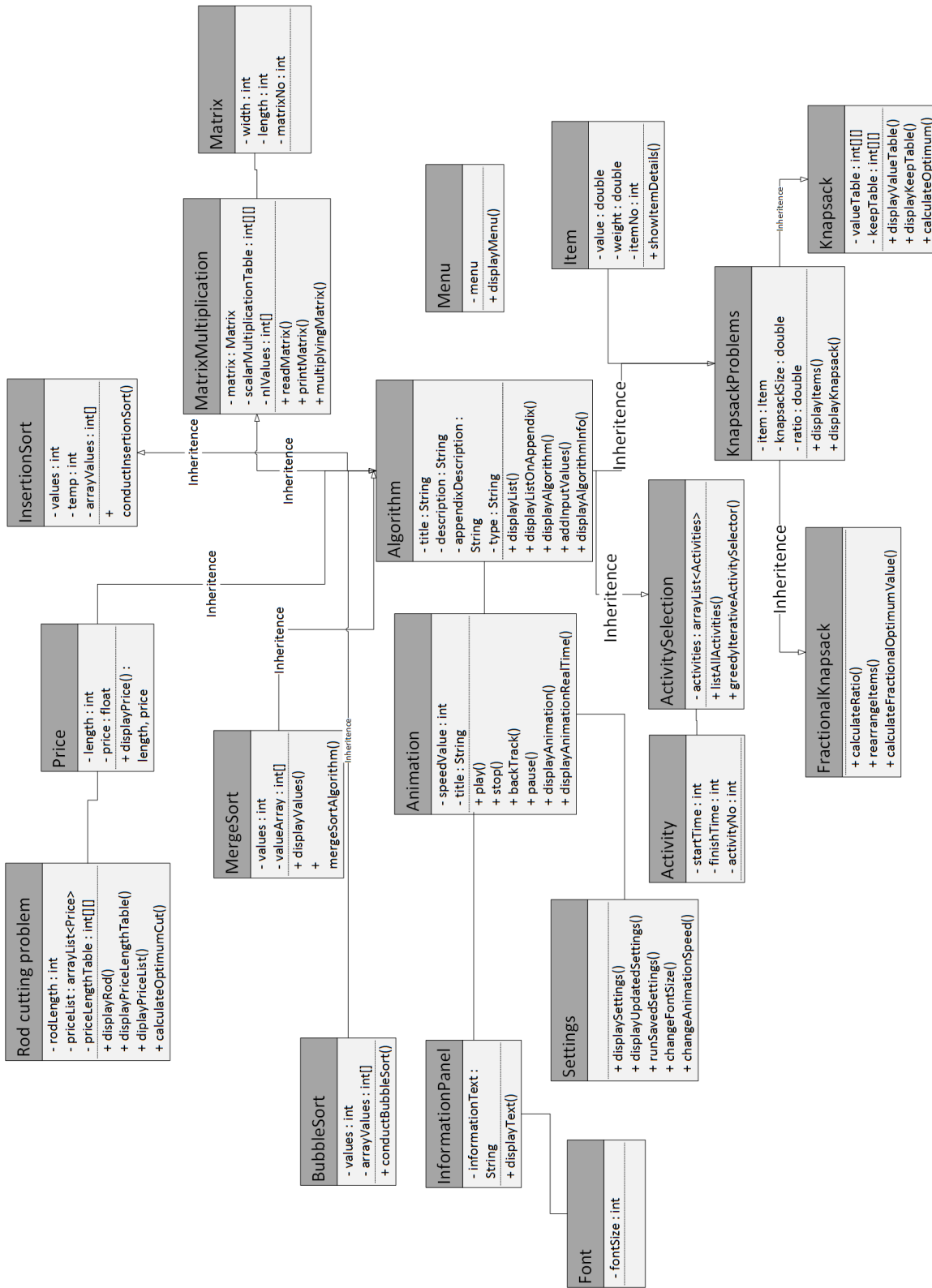


Figure 2.11: The UML class diagram for the *Algorithm Animation Program*

## 2.6 UML Sequence Diagram

Next up, is the sequence diagrams. These diagrams are primarily used to show the interactions between its objects in a sequential order, and the interactions that occur afterwards. The purpose of this diagram is to show in greater detail, compared to the class diagram shown in the previous section (section 2.11), of what objects that are involved during a particular event. Do take note that these diagrams will be separated between the two main features of the program, the *animation* and *settings* feature.

### 2.6.1 The animation feature

The sequence diagram for the animation feature shown in figure 2.12, reveals the interaction between the user and the different objects that are expected to be involved within this feature. 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, which is 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 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.

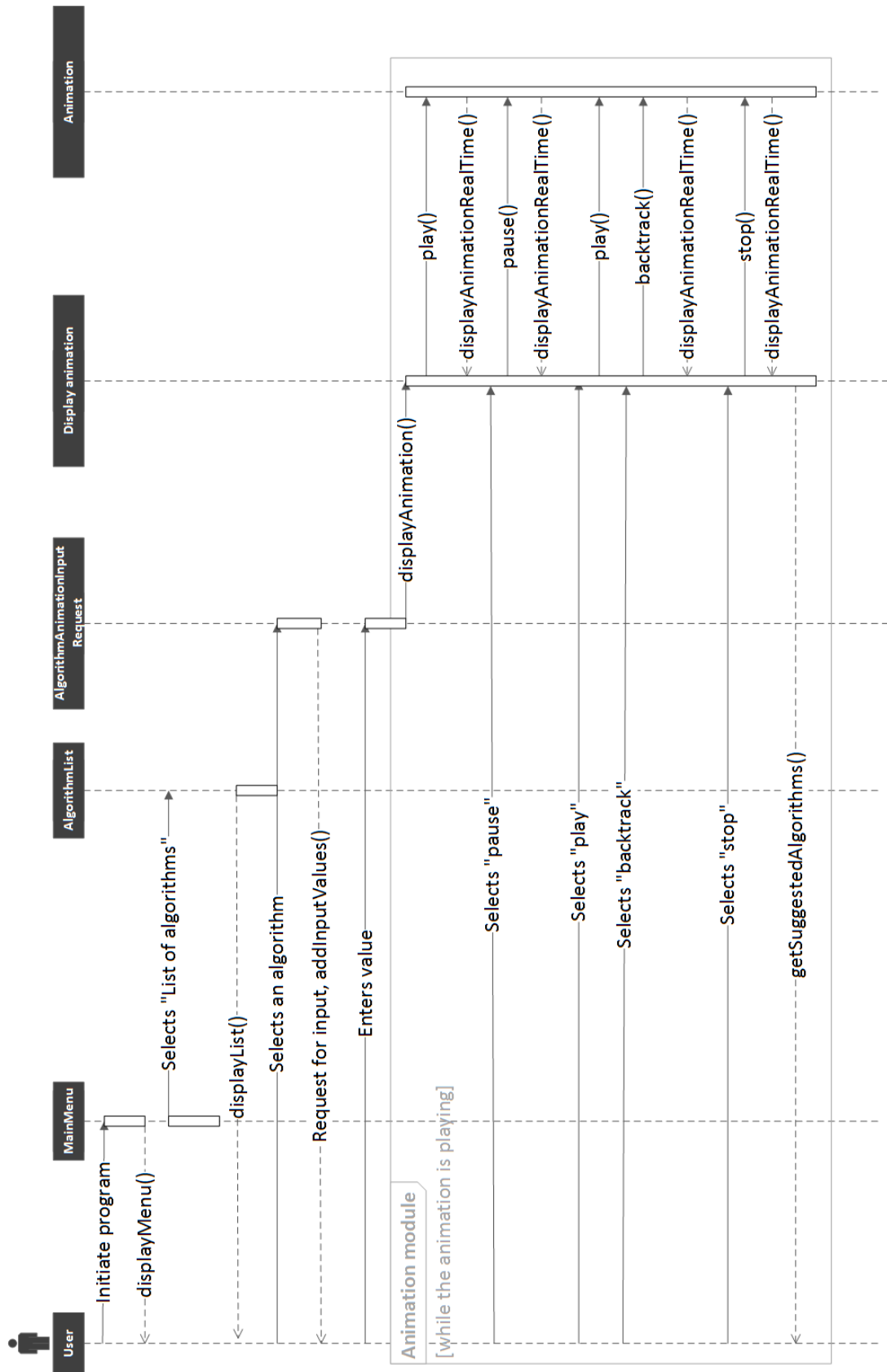


Figure 2.12: The sequence diagram of when the user uses the animation feature.

## 2.6.2 The settings feature

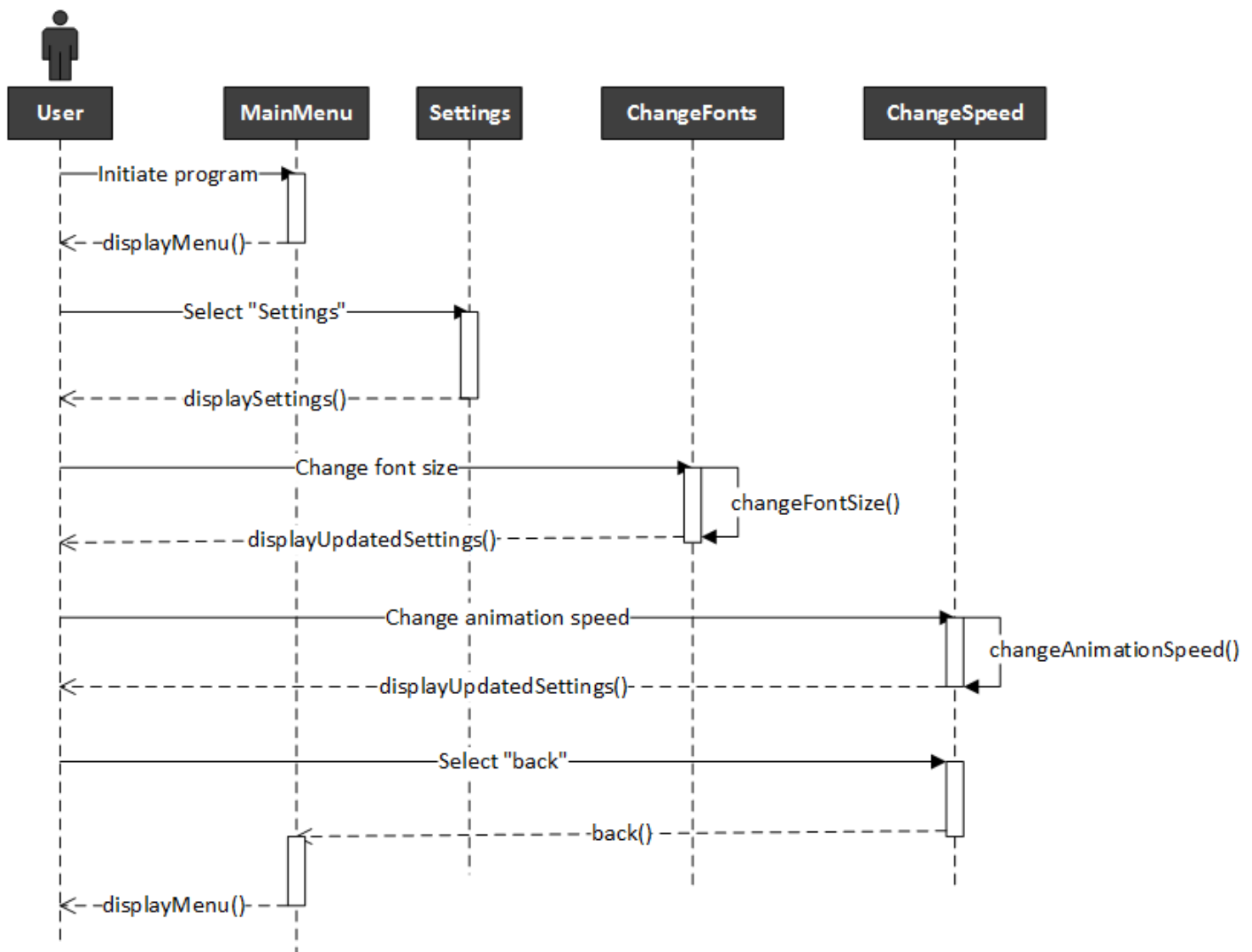


Figure 2.13: The sequence diagram of when the user uses the settings feature.

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

Once the user is in the settings page, the user can change features such as the font size and the animation speed. If the user decides to change the font size, the *changeFontSize()* method is being called out. When the method is called, the method then passes the parameter of the font size chosen by the user, and uses it to make necessary changes to the font size. 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 then 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.

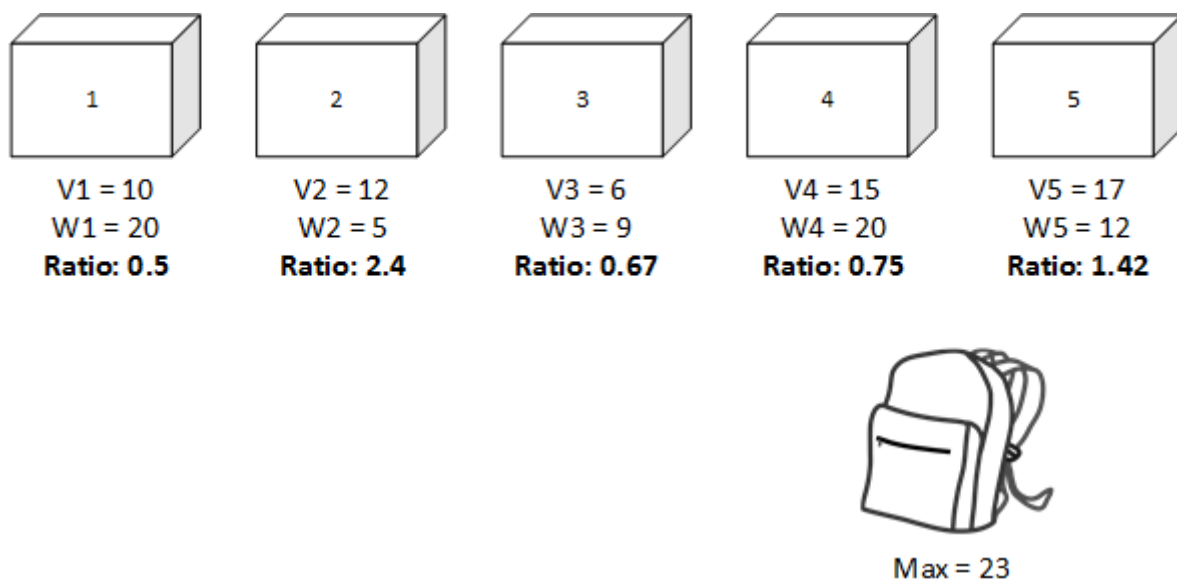


## 2.7 Algorithm animation designs

In this section, I will present you the designs of the animations that will be included in the *Algorithm Animation* program. This section is to propose an idea how the animation will look and act like, and to give a guidance on how to develop them during the implementation stage. Alongside with the design of the animation, I will also include a brief description about the algorithm, and whatever is happening within the animation.

Note that I have not included the control buttons in some of these designs. This section is mainly to emphasize the design of the animation of the algorithm in question. If you would like to refer to the design of the actual graphical interface within the animation page, do have a look at section 2.4, on page 13 for more details.

### 2.7.1 Fractional Knapsack Problem



**Information**

Iteration: 5<sup>th</sup> (for calculating the value to weight ratio of 5 items)

items as you go along.  
Take the one that has the largest value to weight ratio  
(most expensive item per pound)

**STEP 1**  
Calculate the value to weight ratio of each item. [ Value / Weight ]

Figure 2.14: The animation design of the FractionalKnapsackProblem. This shows the initial state of the animation.

The Fractional Knapsack Problem is one of the algorithms that uses a combinatorial optimisation strategy in which the goal is to fill the knapsack with fractional amounts of items until it reaches to its maximised value. This algorithm predominantly uses the greedy method approach in order to reach to its optimal solution. Within this section, I have included the design

of how the animation for this algorithm will turn out to be, along with its descriptions that describes each of the different processes that happens during the play time of the animation.

The graphical interface of the Fractional Knapsack Problem algorithm shown in figure 2.14 is the initial state of the animation. The animation consists of the items, which are represented in cubes, along with its values, i.e. weight and value of the item. Other than the items, there will also be an image of a rucksack that represents the knapsack. The knapsack has its max weight, which is the maximum amount of weight it can possible carry, and the current weight it is carrying now.

The next step of this animation shown in figure, is simply to follow the process of the animation. In this design, the animation is currently at the stage where it needs to calculate each of the items' value to weight ratio. The animation simply adds another value to each of those items called *Ratio*, that shows the results to the calculation. Next would be the part of the animation is when the items are re-arranged according to their value to weight ratios.

Once the items are finally arranged, it is now time to add the items into the knapsack. The animation will represented that by dragging the item in its current iteration next to the knapsack. An arrow will then appear next to the item to represent the act of adding the item into the knapsack. When the item in question is added into the knapsack, there will be a change on the *Current weight* value.

There is an exception to this animation, that the knapsack, can no longer contain the total weight of the item in question. So, the animation program will inform the user, under the information section, that it can't insert the whole of item in question. This proceeds the animation to add fractions of the item instead, and doing a simple calculation ( $\text{ratio} * \text{amount of weight left in the bag}$ ) along it as well. You can clearly see this calculation clearly above the arrow.

As when the calculation is complete, and the knapsack's current weight has reached to its max weight, the animation then comes into a conclusion. The conclusion of this algorithm is that the knapsack is finally full, and the total value that the knapsack has achieved is displayed as well. Afterwards, the animation stops here.

```

1 // array list of the items
  arrayList<Item> listOfItems = new arrayList<Items>;

3
  // calculate the value to weight ratio of each item
4 for (i = 0, initiate from i, end at n){
5     listOfItems.valueToWeightRatio[i] = Item.value / Item.weight
6 }

7
9 // re-arrange the items based on the value to weight ratio
10 for (i = 0, initiate from i, end at n){
11     double temp = 0
12     if (valueToWeightRatio(i) < valueToWeightRatio(i + 1)) {
13         temp = valueToWeightRatio(i+1);
14         valueToWeightRatio(i + 1) = valueToWeightRatio(i);
15         valueToWeightRatio(i) = temp;
16     }
17 }

19 // add the first item of the list into the knapsack
20 for (i = 0, initiate from i, end at n){
21
22     // check the item's weight and the knapsack current capacity and see if it can
23     // carry anymore items
24     if (Knapsack.capacity < Item.weight){
25
26         // start adding fractions
27         Knapsack.weight = per fraction of Item.weight;
28         Knapsack.capacity = Knapsack.capacity - Item.valueToWeightRatio;
29
30         if (Knapsack.capacity is down to 0) {
31             break;
32         }
33     }
34     else (Knapsack.capacity > Item.weight){
35
36         // add the whole item into knapsack
37         Knapsack.weight = Knapsack.weight + Item.weight;
38
39         if (Knapsack.capacity is down to 0) {
40             break;
41         }
42     }
43 }

```

Listing 2.1: The psuedo code of the fractional Knapsack Problem

The psuedo code of the fractional knapsack problem, shown in listing 2.1, is basically the construction of how the algorithm will be put to work during the implementation phase. First the algorithm declares the arrayList of *Item* objects, where an *Item* object will have its attributes such as weight and value. The arrayList will store the list of items, which the user has declared on the input page before the animation starts.

Moving on, the algorithm will then calculate each of the items' value to weight ratio. Using those values, the algorithm then sorts the items out, from the item with the largest value to weight ratio, to the one that has the least. From here, the algorithm starts picking the first item from the list, and adding it into the knapsack. However before doing so, the algorithm checks if there is any space left for the knapsack to take in, by comparing the whole weight of the item to the amount of capacity left the knapsack is able to take in. If there is enough space,

the algorithm takes in the whole item, otherwise, it starts adding each amount of fraction it is able to take before the knapsack capacity reaches to its full amount. When that happens, the algorithm ends.

### 2.7.2 Knapsack Problem

The Knapsack Problem is quite similar compared to the Fractional Knapsack Problem. However for this problem, you can only take the whole item and leave the rest if there is no space left in the knapsack, instead of taking items fractionally until the knapsack is full. Despite a minor change in the constraints of this problem, the approach to the knapsack problem is very different to the fractional one. Instead of utilising the greedy method like we would do for the fractional, this requires us to use the dynamic programming approach instead. Because of this, the animation needs to add another feature, and this will basically be applied to all algorithms that uses the dynamic programming approach as well: tables.

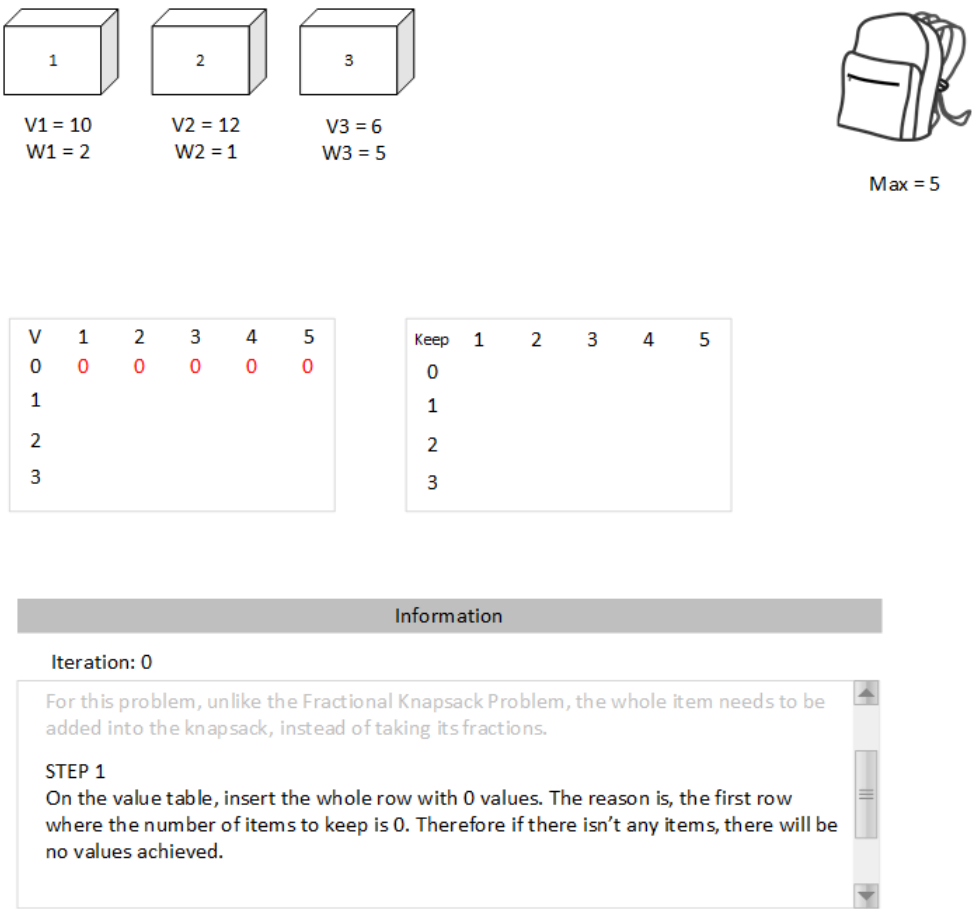


Figure 2.15: The initial state of the animation design of the Knapsack Problem. It shows that it is describing what the tables are.

During the initial phase of the animation (figure 2.15), the animation starts off by displaying information about the use of the *value* and *keep* table. These information will be displayed in yellow callouts, which would be placed around those tables which they are referring to. Its purpose is to inform the user on what these tables are for, before the actual algorithm starts. These texts will remain here for about a 30 seconds, before proceeding to the next state.

Included in this animation, other than the ones mentioned before, are the cube figures which represent the items. Along with them are its attributes, which are their respective value they are worth, and their weight. Next to it is an image of the knapsack. Show below it is its

maximum capacity, and the current weight it is holding. For its initial state, the current value is always 0.

Within the *Information* section, there will also be a brief description of what the algorithm is, and how is it different from the Fractional Knapsack algorithm.

After the explanation phase has completed, the algorithm of the knapsack problem begins. The algorithm begins by applying the sum of values obtained on the first row of the *value table*. Since on the left side of the table is 0, meaning that there are no items selected, all the values are returned as 0 for the first row. The texts that are inserted into the table are turned red, simply to let the users know where to look in the animation. The values are added into the *keep table* as well after adding those values into the *values table* previously.

As the animation proceeds to the second row, where the animation loops by doing the same thing previously on the first row. It refers to the top column, which is the weight of the knapsack to carry, which is highlighted with a green circle. Followed by the spot where the animation needs to compute the value for, which is highlighted with a red circle.

Once filling up the *value* and *keep* table is completed, the algorithm looks through the keep table from the most bottom right hand side, to find out which item to keep. If the value is 1, it means that the item along that row is kept, and the total weight of the knapsack will be subtracted from the item. Do this along the column which is the maximum possible amount of capacity of the knapsack, in this case 5, until either the knapsack is full, or can no longer take in any more items. Finally once it has done that, show the total value (most optimum value you can achieve) that is taken away from the knapsack.

```

// Input :
2 // Values (stored in array v)
  // Weights (stored in array w)
4 // Number of distinct items (n)
  // Knapsack capacity (W)
6
for j from 0 to W do:
8   // 0 throughout the first row, since no items are taken
   m[0, j] := 0
10
  for i from 1 to n do:
12    for j from 0 to W do:
      // if weight[i] of the item is less or equal to the current capacity, j
14      if w[i] <= j then:
        m[i, j] := max(m[i-1, j], m[i-1, j-w[i]] + v[i])
16      else:
        m[i, j] := m[i-1, j]

```

Listing 2.2: The psuedo code of the Knapsack Problem

The code that is shown in listings 2.2, is the psuedo code for the knapsack problem[]. The input for the algorithm is the arrayList of the items, which consists of the value and weight attributes, the number of items in total, and the capacity of the knapsack. Since this problem uses the dynamic programming approach, the 2D array for the value table will be in *tableValues[j][i]*, where *j* is a count until to it reaches to the capacity of the knapsack, and *i* being the counter for the number of items in total.

First, the algorithm inserts 0 values on he first row of the value table, since there are no items are taken. After the row has been fully filled out, the algorithm proceeds in going through the next, and following rows. It first check the *j* value, it being the capacity of 1, and the *i* value, which defines the first item, item 1. It then compares with the weight of item 1 and the capacity amount, to see if item 1 fits. If it does, the algorithm proceeds in find the max value between the current item plus the item that can fit in the remaining capacity (if there is any), and the previous item from the same capacity. Once a max value is found, the algorithm

proceeds to the next  $j$  value until it ends. However, if there is no capacity left since the weight of the item is more than the capacity, the algorithm takes on the previous value instead.

### 2.7.3 Activity Selection Problem

In the Activity Selection Problem, you are given a set of activities, where each have its respective starting and finishing time. Within this set of activities, the goal is to find the most number of activities that can run without interrupting each other. This algorithm uses the greedy method approach in order to find the optimum set of activities.

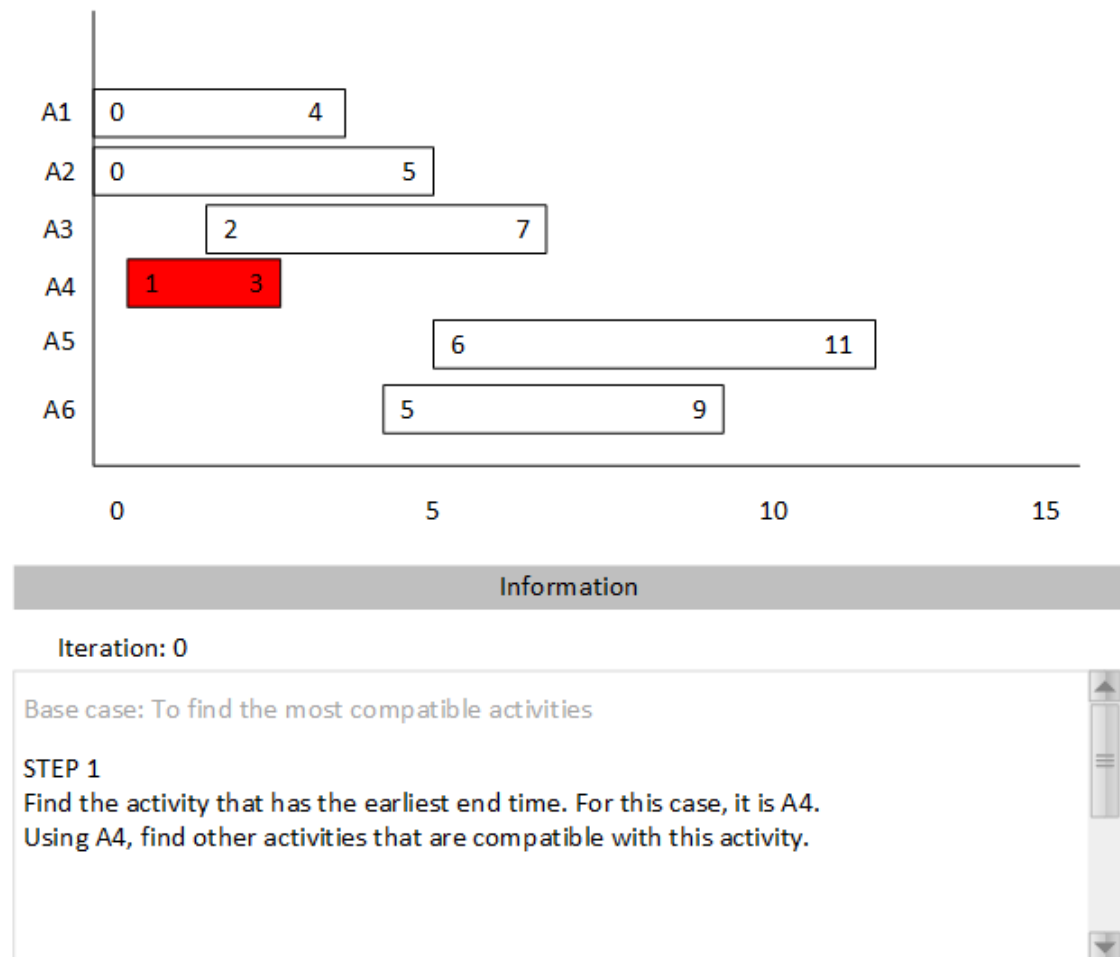


Figure 2.16: The animation design of the Activity Selection Problem.

Shown in figure 2.16, is the initial stage of the activity selection animation during its starting phase. During this phase, the animation starts off by explaining parts of the diagram, using the bright yellow callouts. Along with it, there is a further explanation about the objective of the algorithm within the information section below.

Once the explanation phase is done, the animation carries on by initiating the activity selection problem algorithm. First, it selects the activity with the earliest end time, and highlights it red. Once the activity has been chosen, it goes on by finding the other activities within the list that is incompatible with the chosen activity. These incompatible activities are then removed from the list of activities, and are greyed out in the animation to show that they are removed. Once there aren't any more activities left in the list of activities, the optimal solution to the problem has been finalised. This is when the animation ends.

```

Greedy-Iterative-Activity-Selector(A, s, f):
    Sort A by finish times stored in f'
    S = {A[1]}
    k = 1
    n = A.length
    for i = 2 to n:
        if s[i] < f[k]:
            S = S U {A[i]}
            k = i
    return S

```

Listing 2.3: The psuedo code of the Activity Selection Problem

The psuedo code of the activity selection problem shown in listing 2.3. There will be an arrayList of activities as an input, where the algorithm firstly sorts them by their finish times, earliest to latest. From that list, the algorithm uses the greedy approach by taking the activity that has the earliest time (which is first on the list), and insert into the set S, which will be another arrayList with an *Activity* class type.

Taking n as the length of the remaining activities in the set, the algorithm that iterates through the list to find the activities that are incompatible with the one that is selected through the greedy approach. When this is done, the algorithm conduct a recursion, where it goes from the beginning by calling out the next activity that has the earliest finish time from the updated list. The algorithm goes on until to a point where it has achieved the optimum set of activities.

## 2.7.4 Merge sort

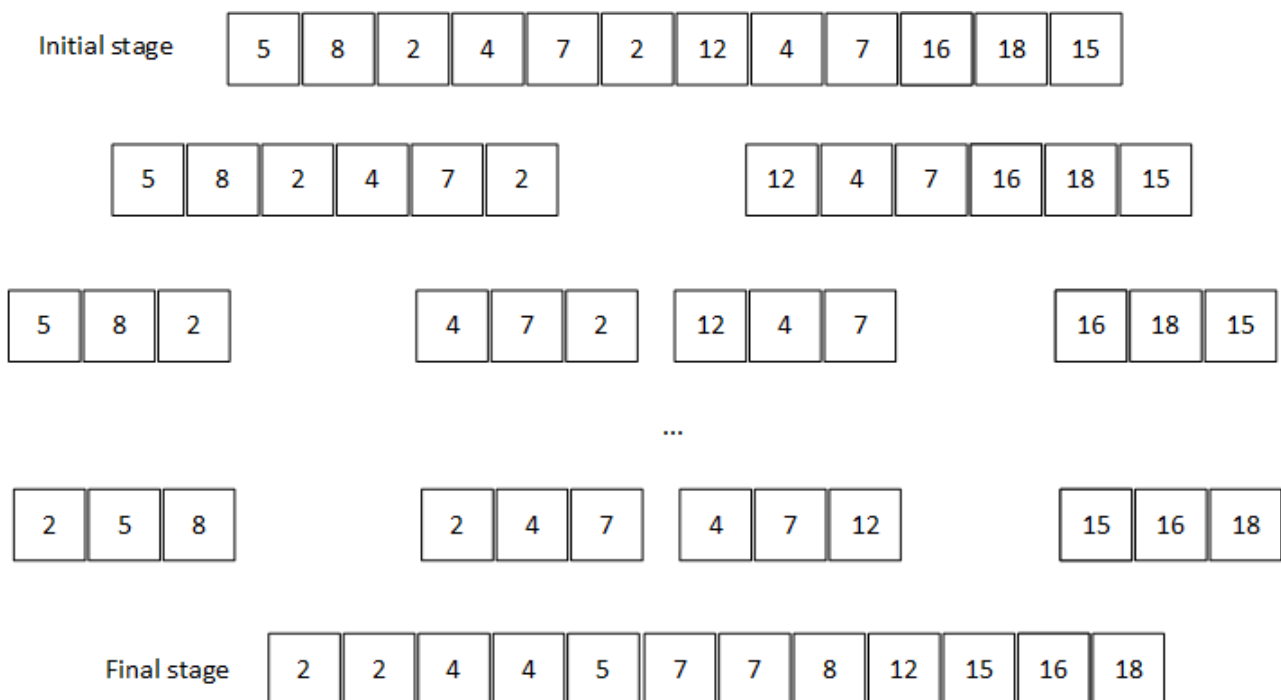


Figure 2.17: Merge sort animation design.

The merge sort algorithm is basically one of the sorting algorithms that uses the divide and conquer method to sort the contents of the array of values. The animation for the merge sort algorithm will emphasize mainly on the idea of a divide and conquer, which is one of the three algorithmic paradigms.

On the input page for the merge sort algorithm, will be the number of elements in array, followed by the values for each element of the array. The animation for this algorithm will be made simple, as you can see in figure 2.17. First, is to have squares that represents each element of the array. These squares will initially be set next to the other squares with values clearly shown on them.

As when the animation starts, the animation will clearly show the division it makes to divide the array into 2 parts, each side with an equal amount of elements to the other side (unless if the total number of elements is an odd number, then one side will have one more element than the other). The animation will keep on doing this until each of the elements divided will be left to one each. After which, the animation will proceed in taking the first element from the unsorted list, sorts and drags it down to another tier, and do the same for the rest until all the elements are sorted and merged as a whole. The animation then concludes by showing that it is finally sorted, and ends here.

### 2.7.5 Matrix multiplication

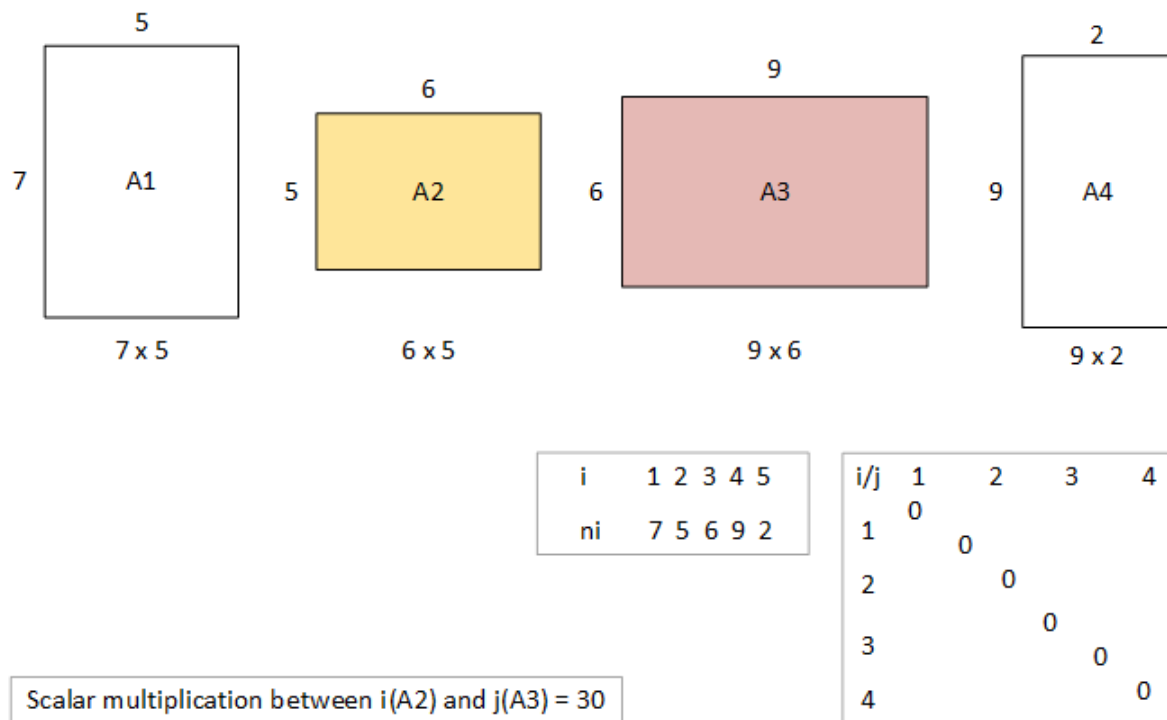


Figure 2.18: Merge sort animation design.

The matrix multiplication problem is classified under the *optimisation problem*, that will be available in animation. This problem simply shows the algorithm on finding the most efficient way to multiply two or more matrices together, and using dynamic programming in order to find the solution.

The input page for the animation will consist of the number of matrices to compute and the size of each of those matrices. There will be some constraint when it comes to selecting the size of the matrix however, is that, the next matrix will need to have one of its sides to be the



same value as one of the sides the first matrix as well, which is a basic rule for two matrices to be multiplied with one another.

On the animation itself, it will present each matrix in a rectangular shaped figures, depending on the size that was given during the input stage. On top of each matrix will also be an identifier, which format is  $M_i$ ,  $i$  being the number of the matrix in the list. Below each of the rectangles will show the size of the matrix, which format goes as  $widthSize * lengthSize$ , in order to depict the size of each rectangles.

During a part of the animation, the algorithm will pick the values for  $i$  and  $j$ , which are the values between the 1, the first matrix, and  $N$ , where it is the number of the last matrix in the list. Between these two values, there will also be  $k$ , which is going to be used to compute the most efficient *split* to be made, in order to achieve the minimal amount of scalar multiplications between the two lists of the matrices. In every iteration of the algorithm, the animation is to use  $k$  as a splitter, and between the two parts of the list, find the minimum amount of scalar multiplications needed. And once the minimum has been found, the algorithm will conclude its answers, and ends.

Since this problem uses dynamic programming, there is a need to add a table that goes with the animation as well. This table is what I call the  $i$  and  $j$  table, which is a two dimensional array that makes up the size of  $i$  and  $j$ . This table is used to store the result of the scalar multiplications between the size of the matrices, and is used to find the most efficient solution for the problem.

### 2.7.6 Rod cutting problem

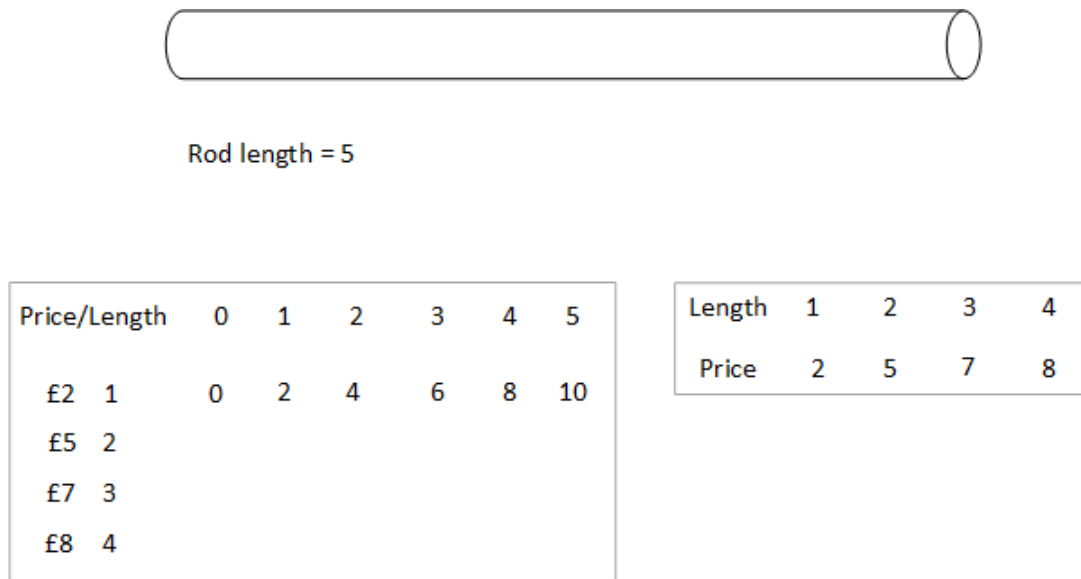


Figure 2.19: Merge sort animation design.

The rod cutting problem is another one of those algorithms that uses the dynamic programming strategy. The problem consists of a rod, which is a  $x$  amount of length. Along with it, there is a table of prices, selling for a certain amount for a certain amount of length. Using some sort of a strategy (for our case, an algorithm), find the best cuts of the rod of  $x$  length, in order to get the most value out of it.

In the input page for the rod cutting problem, would have the input for the length of the rod, and the prices for each length of the rod. When the input is inserted, the animation starts by showing the image of a rod, with the length assigned to it. Below it as well are two tables, one of them, the *Price/Length* table, is the table that is used to calculate the price earned for

selling the rod at a certain length. This table will be filled along the way during the course of the animation. The other table is the *price table*, which lists the set of length and its prices.

The algorithm ends when the *Price/Length* table is fully filled, and the optimum cut is retrieved from the table. The animation will then conclude the optimum price for the particular problem before it terminates.

### 2.7.7 Bubble sort

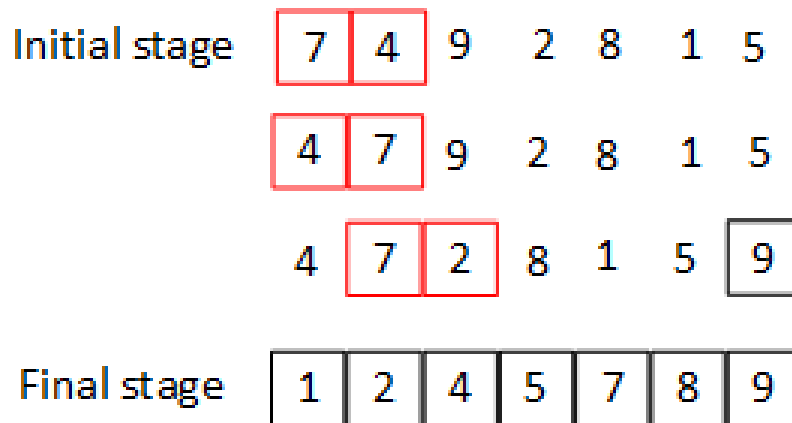


Figure 2.20: Merge sort animation design.

The bubble sort is one of the sorting algorithms that I will include in this program, classified under the *Sorting algorithms* section. It is a simple algorithm that compares each adjacent pair, and swaps with one another, left side is the smaller value, whilst the right side is the larger value. The algorithm keeps doing so until the whole list is fully sorted.

For the input page, the values that the program will take before starting the animation would be, the size of the array, and the values for each of the elements in the array.

The animation for the bubble sort algorithm will show the list of values, arranged accordingly to the input that was given by the user, or the random generator. These values are shown basically depict each of the element of the array, and the animation will show clearly that each of them will be swapped with the value next to itself clearly when it is its time to swap. Once the largest value in the list has moved all the way to the right side of the array, a black border will surround it, indicating that the position for this element has been finalised. The animation will come to an end, once all the elements have its own black border. The animation then concludes that the array of values have been sorted, and will stop itself then.

### 2.7.8 Insertion sort

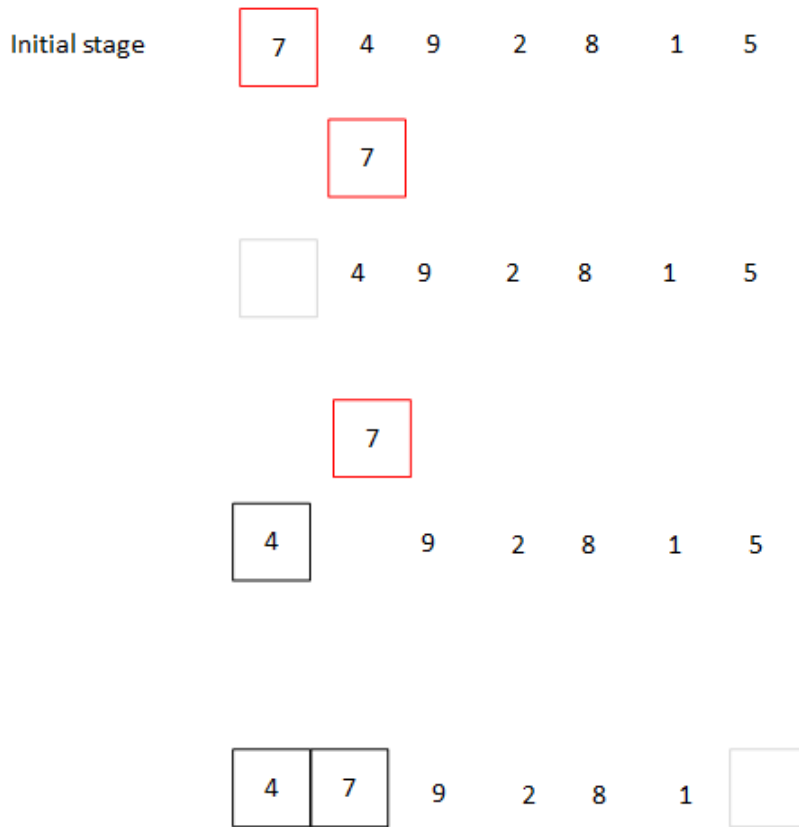


Figure 2.21: The insertion sort animation design.

The input page for the insertion sort will be very similar to the input page for the bubble sort. However, of course, the animation of the insertion sort will be different compared to it. At the initial stage, as seen in figure 2.21, the animation shows the values, where these values represents each element in an array. As the animation begins, the first value from the left will be highlighted with a red bordered square, and then “pulled out” from the main array. This value is then used to compare with the values from the left side, values which are in the black bordered square. The black bordered square is basically to represent the values that the algorithm had gone through, and are sorted. Once the value in the red square has found its place within the values within the black border, the red box for that value changes to black. Then, the next unboxed value will be pulled out the following after.

```
1 for i      1 to length(A) - 1
  j      i
3   while j > 0 and A[j-1] > A[j]
      swap A[j] and A[j-1]
5     j      j - 1
  end while
7 end for
```

Listing 2.4: Simple psuedo code for the insertion sort

## 2.8 The Evaluation Design

The evaluation will asses on the three main criteria that will be used during the assessment phase, which are *usability*, *comprehensiveness*, *correctness*. The term *usability* plainly refers to

the ease of using the program. There are a few pointers for the software to achieve this, which involve in easy installation process, the intuitiveness of its graphical interface, efficient, and its interface is easy to navigate around with and learn.

The next criteria that will be assessed during the evaluation would be the *comprehensiveness* of the program. Since this software is meant to be educational, the software needs to take conscientious measures in making the animation to be easily understood by students, who either have no knowledge or little prior knowledge on the particular subject. Within this criteria, the animations in this program needs to be easily understood, by giving sufficient amount of information that goes hand in hand while the animation is being played. With these two working together, the content that are provided needs to be relevant. These construction of the content that has being displayed are also expected to be clear and concise, and would be easily understood within a short period of time.

The last criteria that needs to be assessed during the evaluation would be the *correctness* of the contents that is provided in the software. This is another important criteria that needs to be assessed during the evaluation, especially for an educational based software, as it is important for the *Algorithm Animation Program* to sustain the correct depiction of the algorithms shown in the program.

### 2.8.1 Testers who will be involved during the evaluation

It is possible that non-human data will be needed when conducting the evaluation of the software. Non-human data refers to their anonymous feedback in regards of the software they have tested. These testers are required to come from two different sets of groups of testers when it comes to the evaluation of this software. The first group will be involving in computer science students, who either have no knowledge in to having basic knowledge in regards to algorithms. The reason why this group will be used to assessed the program is that they will mainly be assessing the usability and the correctness of the program. Since they have no to little knowledge regarding the topic, it is up to them to see if they have managed to achieve any form of understanding after using the program. The measurement of their understanding will able to show the amount of effectiveness in representing the animations. If they manage to do so, it will show that the representation of the animations are effective.

The second group of testers on the other hand, would involve in students, or lecturers who have an extensive knowledge in algorithms. This group will primarily focus on assessing the validation of the animations that are presented to them. With the help of this group of testers, their feedback will ensure that the animations portraying the algorithms correctly, and if not, state in the evaluation form on what are the areas that are portraying the algorithms incorrectly. They will also assess the correctness of the information that comes with the animation as well, and see if the correlation between the information and animation is relevant and valid. Using their feedback will help me in locating the specific errors found within the animation and its information, and rectifying them.

### 2.8.2 The design of the evaluation form

Below in table 2.5, I have included the software evaluation form that is expected to be filled out with feedback from the users who will be testing the software. The form includes in defining each criteria, any sub-criteria that comes along with it, and the notes that is explained in plain language on what each of those criteria means. Which then follows by a series of questions that are involved within each criteria, which the testers are expected to fill their feedback in.

What is expected from the evaluation form is that users are expected to fill in with open ended answers in each sections of the form, describing about their experiences when it comes to

using the software. It is also expected of me to obtain feedback, such as what is good or aspects that is lacking in the program. Of course, the users are to give the feedback of the software based on the criteria that they are assessing from, which would definitely gives me a better sense of direction when there is the need to improve on the software. Of course, afterwards, the form allows the users to give any additional feedback if there is a need to. This might be useful, as it might fill in the gaps that I have missed in the criteria based assessment.

Table 2.5: The design of the evaluation form that will be used for the criteria based assessment.

Criteria	Yes/No, supporting feedback
<b>Usability</b>	
Is the program easily understood in terms of usage?	
Is it easy to navigate around the program?	
Can you see the images displayed in the program clearly?	
Can you see the animation displayed clearly?	
Is the interface of the program easy to use?	
<b>Comprehensiveness</b>	
Do you understand the general structure of the algorithms presented in the program?	
Do you understand how each of the algorithms work? List the ones that you understand and the ones you don't.	
Was it easy for you to understand that the animations are trying to portray?	
What do you think about the display of the animations in general?	
Are the information that comes with the animation can be easily understood?	
Are the information that comes with the animation relevant to the animation?	
<b>Correctness</b>	
Are the representation of the animations for the algorithms it is portraying correct?	
Are the information displayed whilst the animation is playing correct?	
<b>Other feedback</b>	
Are there any thing that is good in the program?	
Are there any that is lacking?	
What do you think that needs to be improved in the software?	

# Chapter 3

## Review against plan

Admittedly, there are a few changes that had deviated slightly from the specification document. One of the minor changes I have made is the exclusion of adding a binary search tree from the list of animations available the program. This is mainly to ensure that I have enough time to implement the animations for other algorithms that had been mentioned in the design chapter, under the *Algorithm animation designs* section (refer to section 2.7 on page 24 for the list of animation designs).

Another change that I decided to make, is to include human testers to conduct the assessment of the *Algorithm Animation Program*. I believe that there is a need for me to include external parties to assess and review my product, instead of doing it myself, as specified in the specification documentation. Reason being that having someone who has a different level of knowledge and understanding in this topic to test this product, would provide me with better feedback, from their point of view, about what is good or lacking in the program. For more information about the evaluation testing, do have a look at section 2.8 on page 34 for more information such as, what kinds of testers that is needed, and the sets of questions and tests that will be conducted in order to make the product ideal for use.

Finally, it is worth mentioning that I have decided to add one extra feature, the *settings* feature, as I believe that this will enhance the user experience when allowing the users to work on an environment that they are most comfortable in. For now, the plans only to include in changing the font size and the speed of animation due to the time constraints that was given to me. However, I am planning to implement the settings feature that would easily allow the developers to add additional features that can be changeable, thus making the program more customisable in result, in possible further iterations of the program.

### 3.1 Updated Gantt Chart

In the following page shows the revised version of the Gantt Chart. It has been changed slightly to fit the plans that I have devised and documented within this design documentation. What has been predominantly change is the testing phase, which is brought much forward, and now currently aligned with the implementation stage. Of course, the testing phase is expected to require a longer time compared to the implementation, as I have set ample amount of time for the testing phase. I believe that this is one of the most important phase for me to invest on and ensure that the software will be in tip top condition before the submission.



ID	Task Name	Start	Finish	Duration	Q4 15												Q1 16												Q2 16											
					27/9	4/10	11/10	18/10	25/10	1/11	8/11	15/11	22/11	29/11	6/12	13/12	20/12	27/12	3/1	10/1	17/1	24/1	31/1	7/2	14/2	21/2	28/2	6/3	13/3	20/3	27/3	3/4	10/4	17/4	24/4	1/5	8/5			
1	Conceptual phase	28/09/2015	22/10/2015	3w 4d																																				
2	Initial meeting with project supervisor	28/09/2015	28/09/2015	1d																																				
3	Writing the conceptual design of the program	28/09/2015	30/09/2015	3d																																				
4	Meeting with project supervisor on specification draft	09/10/2015	09/10/2015	1d																																				
5	Submission of specification report	22/10/2015	22/10/2015	0w																																				
6	Design phase	23/10/2015	30/11/2015	5w 2d																																				
7	Researching on the algorithmic methods that will be animated in the program	23/10/2015	29/10/2015	1w																																				
8	Researching of educational software available in the current market	27/10/2015	02/11/2015	1w																																				
9	Meeting with project supervisor on the initial design	02/11/2015	02/11/2015	0w																																				
10	Preparing the content for design presentation	30/10/2015	10/11/2015	1w 3d																																				
11	2nd meeting with project supervisor on documentation and presentation draft	10/11/2015	10/11/2015	1d																																				
12	Writing of the design report and presentation	23/11/2015	23/11/2015	1d																																				
13	Presenting design of the project to project supervisor	23/11/2015	23/11/2015	0w																																				
14	Implementation phase	30/11/2015	19/02/2016	12w																																				
15	Develop the graphical user interface of the program	30/11/2015	09/12/2015	1w 3d																																				
16	Implementation of the animations for the algorithmic methods	09/12/2015	29/12/2015	3w																																				
17	Developing of user input and integrate it with the animation feature	29/12/2015	11/01/2016	2w																																				
18	Adding of other additional functionalities	01/01/2016	14/01/2016	2w																																				
19	System integration	14/01/2016	03/02/2016	3w																																				
20	System testing	30/11/2015	07/04/2016	18w 4d																																				
21	Writing up of test plan	30/11/2015	04/12/2015	1w																																				
22	Unit testing	04/12/2015	08/02/2016	9w 2d																																				
23	Integration testing	01/01/2016	26/02/2016	8w 1d																																				
24	System test (Validation testing)	22/02/2016	07/04/2016	6w 4d																																				
25	Operational readiness review	07/04/2016	07/04/2016	0w																																				
26	Preparation and presentation stage	20/04/2016	12/05/2016	3w 2d																																				
27	Project preparation followed by submission of interim report	15/02/2016	19/02/2016	1w																																				
28	Preparation of the presentation for the demonstration slides	15/04/2016	21/04/2016	1w																																				
29	Product demonstration	25/04/2016	25/04/2016	0w																																				
30	Submission of the project report	12/05/2016	12/05/2016	0w																																				