

Module Interface Specification for Digital Twin Forest

Team 8, Forest Mirror

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April 4, 2023

1 Revision History

Date	Version	Notes
Jan 14	1.0	First Version
April 4	2.0	Final Version

2 Symbols, Abbreviations and Acronyms

See SRS Documentation at [here](#).

symbol	description
AC	Anticipated Change
DAG	Directed Acyclic Graph
DBH	Diameter at breast height
FR	Functional Requirement
GUI	Graphical User Interface
LAI	Leaf Area Index
M	Module
MG	Module Guide
MVC	Model, Viewer, Controller
NFR	Non-Functional Requirement
OS	Operating System
R	Requirement
SC	Scientific Computing
SRS	Software Requirements Specification
UC	Unlikely Change

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3 Introduction

The following document outlines the Module Interface Specifications for Digital Twin Forest, which is a virtual representation of the real world, including physical objects, processes, relationships, and behaviors. Components of a digital twin encompass data capture and integration, visualization, and advanced analysis including AI, automation, information sharing and collaboration. This project can benefit two groups of users: forest owners who can utilize the software for forest management and meteorologists who can use it for research purposes. Complementary documents include the [System Requirement Specifications](#) and [Module Guide](#).

4 Notation

The structure of the MIS for modules comes from [Hoffman and Strooper \(1995\)](#), with the addition that template modules have been adapted from [Ghezzi et al. \(2003\)](#). The mathematical notation comes from Chapter 3 of [Hoffman and Strooper \(1995\)](#). For instance, the symbol $:=$ is used for a multiple assignment statement and conditional rules follow the form $(c_1 \Rightarrow r_1 | c_2 \Rightarrow r_2 | \dots | c_n \Rightarrow r_n)$.

The following table summarizes the primitive data types used by Digital Twin Forest.

Data Type	Notation	Description
string	String	a sequence of characters
character	char	a single symbol or digit
integer	\mathbb{Z}	a number without a fractional component in $(-\infty, \infty)$
natural number	\mathbb{N}	a number without a fractional component in $[1, \infty)$
real	\mathbb{R}	any number in $(-\infty, \infty)$
Boolean	Boolean	a value that takes either True or False

The specification of Digital Twin Forest uses some derived data types: sequences, strings, and tuples. Sequences are lists filled with elements of the same data type. Strings are sequences of characters. Tuples contain a list of values, potentially of different types. In addition, Digital Twin Forest uses functions, which are defined by the data types of their inputs and outputs. Local functions are described by giving their type signature followed by their specification.

5 Module Decomposition

Table 1: Module Hierarchy(First Controller Table)

Level 1	Level 2
Controller Modules	M1: JsonFileReader
	M2: JsonFileWriter
	M3: PauseManager
	M4: PlayerMovement
	M5: NewDataInputBoxController
	M6: StartButtonController
	M7: InstructionButtonController
	M8: UpdateDataButtonController
	M9: ContactUsButtonController
	M10: QuitButtonController
	M11: BackButtonController
	M12: PlotSelectionDropDownController
	M13: TreeTypeSelectionDropDownController
	M14: ShowEnvDataButtonController
	M15: ShowTreeParamButtonController
	M16: EnvDataSelectionButtonController
	M17: DataTypeSelectionButtonsController
	M18: SaveButtonController

Table 2: Module Hierarchy(Second Controller Table)

Level 1	Level 2
Controller Modules	M19: FileWriter
	M20: FileReader
	M21: SeasonChangeController
	M22: movePanelController
	M23: treePlantingController
	M24: TreeSwitchButtonController
	M25: pieChartButtonController
	M26: pieChartController
	M27: SeasonChangeButtonController
	M28: TreeSwitchController

Table 3: Module Hierarchy(Models)

Level 1	Level 2
Model Modules	M29: ForestTrees
	M30: ForestSky
	M31: ForestTerrain
	M32: RedPine
	M33: Oak
	M34: Beech
	M35: Birch
	M36: WhitePine
	M37: RedMaple
	M38: RedOak
	M39: EnvData
	M40: PlotData
	M41: FirstPersonPlayer
	M42: JsonFile

Table 4: Module Hierarchy(First Viewers Table)

Level 1	Level 2
Viewer Modules	M43: MainPageDisplay
	M44: StartButton
	M45: InstructionButton
	M46: ContactUsButton
	M47: QuitButton
	M48: InstructionInfoDisplay
	M49: ContactUsInfoDisplay
	M50: BackButton
	M51: UpdateDataDisplay
	M52: EnvDataSelectionButton
	M53: DataTypeSelectionButtons
	M54: NewDataInputBox
	M55: SaveButton

Table 5: Module Hierarchy(Second Viewers Table)

Level 1	Level 2
Viewer Modules	M56: CurrentDataDisplay
	M57: PlotSelectionDropDown
	M58: TreeTypeSelectionDropDown
	M59: UpdateDataButton
	M60: ForestDisplay
	M61: ShowEnvDataButton
	M62: ShowTreeParamButton
	M63: EnvDataDisplay
	M64: TreeParamDisplay
	M65: PauseIndicatorDisplay
	M66: SeasonChangeButton
	M67: pieChartButton
	M68: TreeSwitchButton

6 MIS of Json File Reader (M1)

6.1 Module

JsonFileReader

6.2 Uses

UnityEngine

System.IO

UnityEngine.UI

M64

M63

M23

M26

M40

6.3 Syntax

6.3.1 Exported Constants

None

6.3.2 Exported Access Programs

Name	In	Out	Exceptions
Awake			
Start			
readfile	\mathbb{Z}		

6.4 Semantics

6.4.1 State Variables

treeParamDisplay: TreeParamDisplay

envDataDisplay: EnvDataDisplay

graphMaker: pieChartMaker

treePlanter: treePlanting

DataModelObj: DataModel

JsonModelObj: JsonModel

plotNumber: \mathbb{Z}

filePath: string

plotJsonData: string

6.4.2 Environment Variables

overalldata.json
plot1data.json
plot2data.json
plot3data.json
plot4data.json
plot5data.json
plot6data.json
plot7data.json
plot8data.json
plot9data.json
plot10data.json
plot11data.json
plot12data.json
plot13data.json
plot14data.json

6.4.3 Assumptions

None

6.4.4 Access Routine Semantics

Awake():

- transition: readfile(0)
- output: None
- exception: None

Start():

- transition: None
- output: None
- exception: None

readfile(value):

- transition: Open the JSON file according to value, read all the content from the JSON file, update tree parameters of treeParamDisplay, update environmental data in envDataDisplay, invoke the markChart() function of graphMaker, and invoke plantTrees() function of treePlanter
- output: None
- exception: None

6.4.5 Local Functions

None

7 MIS of Json File Writer (M2)

7.1 Module

JsonFileWriter

7.2 Uses

UnityEngine

TMPro

Text

UnityEngine.UI

M1

7.3 Syntax

7.3.1 Exported Constants

None

7.3.2 Exported Access Programs

Name	In	Out	Exceptions
Awake			
updateHandler			InvalidInputException
writeFile	String		
removeMsg			
isValid	String	Boolean	
isIN	char, List<char>	Boolean	

7.4 Semantics

7.4.1 State Variables

indicator: ValueIndicator

inputField: TMP.InputField

notify: Text

FR: FileReader

7.4.2 Environment Variables

overalldata.json

plot1data.json

plot2data.json

plot3data.json
plot4data.json
plot5data.json
plot6data.json
plot7data.json
plot8data.json
plot9data.json
plot10data.json
plot11data.json
plot12data.json
plot13data.json
plot14data.json

7.4.3 Assumptions

None

7.4.4 Access Routine Semantics

Awake():

- transition: Invoke removeMsg()
- output: None
- exception: None

updateHandler():

- transition: Validate the input of the text field and invoke writeFile function
- output: None
- exception: Throw InvalidInputException if the inputs are invalid

writeFile(newValue):

- transition: Import the data from the text field and use it to rewrite the data stored in the JSON files based on the attributes of the indicator
- output: None
- exception: None

removeMsg():

- transition: notify.text := ""

- output: None
- exception: None

isValid(s):

- transition: Check whether all the characters in s are in the pool
- output: True if all the characters in s are in the pool. False otherwise
- exception: None

isIN(target, pool):

- transition: Find an element of pool that matches target
- output: True if that element exists. False otherwise
- exception: None

7.4.5 Local Functions

None

8 MIS of Pause Manager (M3)

8.1 Module

PauseManager

8.2 Uses

UnityEngine

UnityEngine.UI

8.3 Syntax

8.3.1 Exported Constants

None

8.3.2 Exported Access Programs

Name	In	Out	Exceptions
Start			
Update			

8.4 Semantics

8.4.1 State Variables

isPaused: Boolean

pauseIndicator: Image

8.4.2 Environment Variables

None

8.4.3 Assumptions

None

8.4.4 Access Routine Semantics

Start():

- transition: enable the visibility of the Pause image

- output: None
- exception: None

Update():

- transition: Capture the event of pressing the K-key, change the value of isPaused, and enable or disable the visibility of the Pause image
- output: None
- exception: None

8.4.5 Local Functions

None

9 MIS of Player Movement(M4)

9.1 Module

PlayerMovement

9.2 Uses

UnityEngine

9.3 Syntax

9.3.1 Exported Constants

None

9.3.2 Exported Access Programs

Name	In	Out	Exceptions
Update			

9.4 Semantics

9.4.1 State Variables

controller: CharacterController speed: \mathbb{R}

9.4.2 Environment Variables

None

9.4.3 Assumptions

None

9.4.4 Access Routine Semantics

- transition: Change the position of the camera in each frame
- output: None
- exception: None

9.4.5 Local Functions

None

10 MIS of New Data Input Box Controller (M5)

10.1 Module

NewDataInputBoxController

10.2 Uses

UnityEngine

10.3 Syntax

10.3.1 Exported Constants

None

10.3.2 Exported Access Programs

None

10.4 Semantics

10.4.1 State Variables

None

10.4.2 Environment Variables

None

10.4.3 Assumptions

None

10.4.4 Access Routine Semantics

None

10.4.5 Local Functions

None

11 MIS of Start Button Controller (M6)

11.1 Module

StartButtonController

11.2 Uses

UnityEngine

11.3 Syntax

11.3.1 Exported Constants

None

11.3.2 Exported Access Programs

Name	In	Out	Exceptions
OnClick			

11.4 Semantics

11.4.1 State Variables

None

11.4.2 Environment Variables

None

11.4.3 Assumptions

None

11.4.4 Access Routine Semantics

OnClick():

- transition: Enable the visibility of M60
- output: None
- exception: None

11.4.5 Local Functions

None

12 MIS of Instruction Button Controller (M7)

12.1 Module

InstructionButtonController

12.2 Uses

None

12.3 Syntax

12.3.1 Exported Constants

None

12.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick			

12.4 Semantics

12.4.1 State Variables

None

12.4.2 Environment Variables

None

12.4.3 Assumptions

None

12.4.4 Access Routine Semantics

onClick():

- transition: Enable the visibility of M48
- output: None
- exception: None

12.4.5 Local Functions

None

13 MIS of Update Data Button Controller (M8)

13.1 Module

UpdateDataButtonController

13.2 Uses

UnityEngine
UnityEngine.UI
Json File Reader
Value Indicator
M1

13.3 Syntax

13.3.1 Exported Constants

None

13.3.2 Exported Access Programs

Name	In	Out	Exceptions
UpdateEnvDataButtonHandle UpdateTreeParamHandle onClick			

13.4 Semantics

13.4.1 State Variables

EnvDataOptions: Canvas
TreeParamOptions: Canvas
treeSelection: Dropdown
indicator: ValueIndicator
FR: FileReader

13.4.2 Environment Variables

None

13.4.3 Assumptions

None

13.4.4 Access Routine Semantics

UpdateEnvDataButtonHandle():

- transition: Change the isEnvData and isTreeParam variables in the indicator.
- output: None
- exception: None

UpdateTreeParamHande():

- transition: Change the isTreeParam and isEnvData, in the indicator, and also change the TreeType attribute in the indicator according to the value of the Dropdown class.
- output: None
- exception: None

onClick():

- transition: Invoke UpdateEnvDataButtonHandle() and UpdateTreeParamHande()
- output: None
- exception: None

13.4.5 Local Functions

None

14 MIS of Contact Us Button Controller (M9)

14.1 Module

ContactUsButtonController

14.2 Uses

UnityEngine

14.3 Syntax

14.3.1 Exported Constants

None

14.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick			

14.4 Semantics

14.4.1 State Variables

None

14.4.2 Environment Variables

None

14.4.3 Assumptions

None

14.4.4 Access Routine Semantics

onClick():

- transition: Enable the visibility of M49
- output: None
- exception: None

14.4.5 Local Functions

None

15 MIS of Quit Button Controller (M10)

15.1 Module

QuitButtonController

15.2 Uses

UnityEngine

15.3 Syntax

15.3.1 Exported Constants

None

15.3.2 Exported Access Programs

Name	In	Out	Exceptions
QuitSoftware			
onClick			

15.4 Semantics

15.4.1 State Variables

None

15.4.2 Environment Variables

None

15.4.3 Assumptions

None

15.4.4 Access Routine Semantics

QuitSoftware():

- transition: Quit the software.
- output: None
- exception: None

onClick():

- transition: Invoke QuitSoftware()
- output: None
- exception: None

15.4.5 Local Functions

None

16 MIS of Back Button Controller (M11)

16.1 Module

BackButtonController

16.2 Uses

UnityEngine

UnityEngine.SceneManagement

16.3 Syntax

16.3.1 Exported Constants

None

16.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
Back			

16.4 Semantics

16.4.1 State Variables

viewState

upperLevelPage

16.4.2 Environment Variables

Mouse

16.4.3 Assumptions

None

16.4.4 Access Routine Semantics

Back():

- transition: $\text{upperLevelPage} \implies (\text{viewState} := \text{upperLevelPage})$
- output: None

- exception: None

16.4.5 Local Functions

None

17 MIS of Plot Selection Drop Down Controller (M12)

17.1 Module

PlotSelectionDropDownController

17.2 Uses

UnityEngine.UI

UnityEngine.SceneManagement

System.Threading

17.3 Syntax

17.3.1 Exported Constants

None

17.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
displayMenu			
extractTreeParam	s: int		

17.4 Semantics

17.4.1 State Variables

isActive: Boolean

s1: String

s2: String

s3: String

s4: String

s5: String

currentIndex: int

17.4.2 Environment Variables

Mouse

DataModelObj: The gameobject of the current script

EnvDisp: Interface that will be displayed in Unity

dropDown: Drop down menu to select plot

17.4.3 Assumptions

None

17.4.4 Access Routine Semantics

displayMenu():

- transition: $\text{isActive} := \neg \text{isActive}$
- output: None
- exception: None

extractTreeParam(s):

- transition: Get the mouse click, assign different values to s_1, s_2, s_3, s_4, s_5 based on the value of curIndex
- output: None
- exception: None

17.4.5 Local Functions

None

18 MIS of Tree Type Selection Drop Down Controller(M13)

18.1 Module

TreeTypeSelectionDropDownController

18.2 Uses

UnityEngine.UI

UnityEngine.SceneManagement

System.Threading

18.3 Syntax

18.3.1 Exported Constants

None

18.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
displayMenu			
extractTreeParam	s: int		

18.4 Semantics

18.4.1 State Variables

isActive: Boolean

curIndex: int

s1: String

s2: String

s3: String

s4: String

18.4.2 Environment Variables

Mouse

DataModelObj: The gameobject of the current script

TreeParamDisp: Interface that will be displayed in Unity

dropdown: The drop down menu to select tree type

18.4.3 Assumptions

None

18.4.4 Access Routine Semantics

displayMenu():

- transition: $\text{isActive} := \neg \text{isActive}$
- output: None
- exception: None

extractTreeParam(s):

- transition: Get the mouse click, assign different values to s1,s2,s3,s4 based on the value of curIndex
- output: None
- exception: None

18.4.5 Local Functions

None

19 MIS of Show Environmental Data Button Controller (M14)

19.1 Module

ShowEnvDataButtoController

19.2 Uses

UnityEngine
UnityEngine.UI

19.3 Syntax

19.3.1 Exported Constants

None

19.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
EnvDataDispHandle			

19.4 Semantics

19.4.1 State Variables

displayEnvData: Boolean

19.4.2 Environment Variables

Mouse

19.4.3 Assumptions

None

19.4.4 Access Routine Semantics

EnvDataDispHandle():

- transition: $\text{displayEnvData} := \neg \text{displayEnvData}$
- output: None

- exception: None

19.4.5 Local Functions

None

20 MIS of Show Tree Parameter Button Controller(M15)

20.1 Module

ShowTreeParamButtonController

20.2 Uses

UnityEngine
UnityEngine.UI

20.3 Syntax

20.3.1 Exported Constants

None

20.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
TreeParamDispHandle			

20.4 Semantics

20.4.1 State Variables

isActive: Boolean

20.4.2 Environment Variables

Mouse

20.4.3 Assumptions

None

20.4.4 Access Routine Semantics

TreeParamDispHandle():

- transition: $\text{isActive} := \neg \text{isActive}$
- output: None
- exception: None

20.4.5 Local Functions

None

21 MIS of Environmental Selection Button Controller(M16)

21.1 Module

EnvDataSelectionButtonController

21.2 Uses

UnityEngine
UnityEngine.UI

21.3 Syntax

21.3.1 Exported Constants

None

21.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
displayEnvSel			

21.4 Semantics

21.4.1 State Variables

isActive: Boolean

21.4.2 Environment Variables

Mouse

21.4.3 Assumptions

None

21.4.4 Access Routine Semantics

displayEnvSel():

- transition: $\text{isActive} := \neg \text{isActive}$
- output: None
- exception: None

21.4.5 Local Functions

None

22 MIS of Data Type Selection Buttons Controller(M17)

22.1 Module

DataTypeSelectionButtonsController

22.2 Uses

UnityEngine
UnityEngine.UI

22.3 Syntax

22.3.1 Exported Constants

None

22.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
displayDataTypeSel			

22.4 Semantics

22.4.1 State Variables

isActive: Boolean

22.4.2 Environment Variables

Mouse

22.4.3 Assumptions

None

22.4.4 Access Routine Semantics

displayDataTypeSel():

- transition: $\text{isActive} := \neg \text{isActive}$
- output: None
- exception: None

22.4.5 Local Functions

None

23 MIS of Save Button Controller(M18)

23.1 Module

SaveButtonController

23.2 Uses

UnityEngine
UnityEngine.UI
M19

23.3 Syntax

23.3.1 Exported Constants

None

23.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick	mouse click		
Save	updatedData: float		

23.4 Semantics

23.4.1 State Variables

originalData: float
updatedData: float

23.4.2 Environment Variables

Mouse

23.4.3 Assumptions

None

23.4.4 Access Routine Semantics

Save():

- transition: originalData := updatedData
- output: None

- exception: None

23.4.5 Local Functions

None

24 MIS of File Writer(M19)

24.1 Module

FileWriter

24.2 Uses

UnityEngine

UnityEngine.UI

TMPPro

System.IO

Newtonsoft.Json

24.3 Syntax

24.3.1 Exported Constants

None

24.3.2 Exported Access Programs

Name	In	Out	Exceptions
Awake			
updateHandler			InvalidInput
writeFile	inputText: String		

24.4 Semantics

24.4.1 State Variables

indicator: Forest data type of the input

inputField: Textbox of the input

inputText: input to the textbox

notify: text

FR: FileReader

JSON file

24.4.2 Environment Variables

None

24.4.3 Assumptions

None

24.4.4 Access Routine Semantics

Awake():

- transition: notify := NULL
- output: None
- exception: None

updateHandler():

- transition: notify := “Updated”
inputField := NULL
Update the JSON file if the input is valid.
- output: None
- exception: $inputText == NULL \vee inputText \in \{(a, A), (z, Z)\}$

writeFile(inputText):

- transition: Use inputText to update the JSON files
- output: None
- exception: $inputText == NULL \vee inputText \in \{(a, A), (z, Z)\}$

24.4.5 Local Functions

removemsg():

- transition: notify := NULL
- output: None
- exception: None

isValid(s: string):

- transition: None
- output: Boolean
- exception: None

isIN(target: char, pool: char[]):

- transition: None
- output: Boolean
- exception: None

25 MIS of File Reader(M20)

25.1 Module

FileWriter

25.2 Uses

UnityEngine

UnityEngine.UI

TMPro

System.IO

Newtonsoft.Json

25.3 Syntax

25.3.1 Exported Constants

None

25.3.2 Exported Access Programs

Name	In	Out	Exceptions
readEnvData			
readTreeParam			
clearText			

25.4 Semantics

25.4.1 State Variables

indicator: Forest data type of the input

JsonModelObj:

currentValueDisp: Output shown JSON file

25.4.2 Environment Variables

None

25.4.3 Assumptions

None

25.4.4 Access Routine Semantics

readEnvData():

- transition: filePath := "../dataCenter/plot" + plotNumber.ToString() + "data.json";
plotJsonData := File.ReadAllText(filePath);
JsonModelObj := Newtonsoft.Json.JsonConvert.DeserializeObject<JsonModel>(plotJsonData);
EnvDataType := indicator.EnvDataType;
currentValueDisp.text := currentValueDisp.text + JsonModelObj.envDataType.EnvDataType
- output: None
- exception: None

readTreeParam():

- transition: filePath := "../dataCenter/plot" + plotNumber.ToString() + "data.json";
plotJsonData := File.ReadAllText(filePath);
JsonModelObj := Newtonsoft.Json.JsonConvert.DeserializeObject<JsonModel>(plotJsonData);
TreeType := indicator.TreeType;
TreeParamType := indicator.TreeParamType;
currentValueDisp.text := currentValueDisp.text + JsonModelObj.TreeType.TreeParamType
- output: None
- exception: None

clearText():

- transition: currentValueDisp.text := None;
- output: None
- exception: None

25.4.5 Local Functions

None

26 MIS of Season Change Controller(M21)

26.1 Module

SeasonChangeController

26.2 Uses

UnityEngine

UnityEngine.UI

treePlantingController

SeasonChangeButtonController

26.3 Syntax

26.3.1 Exported Constants

None

26.3.2 Exported Access Programs

Name	In	Out	Exceptions
Awake			
changeSeason			

26.4 Semantics

26.4.1 State Variables

haveLeaves: If the trees have leaves

seasonChangeBut: Season Change button

Snow: Particle System for snowing effects

26.4.2 Environment Variables

None

26.4.3 Assumptions

None

26.4.4 Access Routine Semantics

Awake():

- transition: `seasonChangeBut.image.sprite := summerImage;`
`Snow.gameObject.SetActive(false)`
- output: `None`
- exception: `None`

`changeSeason():`

- transition: `haveLeaves := !haveLeaves;`
`(haveLeaves \implies Snow.gameObject.SetActive(false) \wedge (seasonChangeBut.image.sprite := summerImage));`
`(!haveLeaves \implies Snow.gameObject.SetActive(true) \wedge (seasonChangeBut.image.sprite := winterImage))`
- output: `None`
- exception: `None`

26.4.5 Local Functions

`None`

27 MIS of move Panel Controller(M22)

27.1 Module

movePanelController

27.2 Uses

27.3 Syntax

27.3.1 Exported Constants

None

27.3.2 Exported Access Programs

Name	In	Out	Exceptions
myClick			
Update			

27.4 Semantics

27.4.1 State Variables

27.4.2 Environment Variables

```
float speed = 2000f;  
float speed2 = -2000f;  
bool isActive = false;  
bool isShown = false;  
bool isActive2 = false;  
bool isShown2 = false;  
int l.boundary = -400;  
int r.boundary = 350;  
int l.boundary2 = 3100;  
int r.boundary2 = 3850;  
GameObject go;  
GameObject go2;
```

27.4.3 Assumptions

None

27.4.4 Access Routine Semantics

myClick():

- transition: $(\text{atBoundary}() \implies (\text{isActive} := \text{true} \wedge \text{isShown} := \text{false}))$
 $\wedge (!\text{atBoundary}() \implies (\text{isActive} := \text{false} \wedge \text{isShown} := \text{true}))$
- output: None
- exception: None

Update():

- transition: $((\text{isActive} \wedge \text{isShown}) \implies \text{go.transform.Translate}(\text{speed} * \text{Time.deltaTime}, 0, 0) \wedge ((\text{go.transform.position.x} \leq \text{r_boundary}) \implies (\text{isShown} := \text{true})))$
 $((!\text{isActive} \wedge !\text{isShown}) \implies \text{go.transform.Translate}(-\text{speed} * \text{Time.deltaTime}, 0, 0);$
 $\wedge ((\text{go.transform.position.x} \leq \text{l_boundary}) \implies (\text{isShown} := \text{true})))$
 $((\text{isActive2} \wedge \text{isShown2}) \implies \text{go2.transform.Translate}(\text{speed2} * \text{Time.deltaTime}, 0,$
 $0) \wedge ((\text{go2.transform.position.x} \leq \text{l_boundary2}) \implies (\text{isShown} := \text{true})))$
 $((!\text{isActive2} \wedge !\text{isShown2}) \implies \text{go2.transform.Translate}(-\text{speed2} * \text{Time.deltaTime}, 0,$
 $0); \wedge ((\text{go2.transform.position.x} \leq \text{r_boundary2}) \implies (\text{isShown} := \text{true})))$
- output: None
- exception: None

27.4.5 Local Functions

atBoundary():

- transition: $x := \text{go.transform.position.x}$
- output: $x \leq \text{l_boundary}$
- exception: None

28 MIS of Tree Planting Controller(M23)

28.1 Module

treePlantingController

28.2 Uses

UnityEngine

UnityEngine.UI

seasonController

28.3 Syntax

28.3.1 Exported Constants

None

28.3.2 Exported Access Programs

Name	In	Out	Exceptions
plantTrees	plotNumberIndex		
cleanTrees			

28.4 Semantics

28.4.1 State Variables

28.4.2 Environment Variables

Related measures in unity tree editor:

double redPineHSR = 25.0;

double oakHSR = 17.2 / 2;

double beechHSR = 35.47 / 2;

double birchHSR = 22.18 / 2;

double redMapleHSR = 14.12 / 2;

double whitePineHSR = 64.4 / 2;

double redOakHSR = 18.95 / 2

Plot Information:

double sideLength = 100.0;

float startingCoordinate = 1f;

float endingCoordinate = 99f

Collection of tree positions:

Vector3[] treelocal

Treepfabs with leaves:

List< *GameObject* >treeprefabsWL

Treepfabs without leaves:

List< *GameObject* > treeprefabsWOL

ListOfCircles circles[plotNumberIndex]

28.4.3 Assumptions

None

28.4.4 Access Routine Semantics

plantTrees(plotNumberIndex):

- transition: generateCircleLocation(circles(plotNumberIndex),differentTreeNumbers.Sum());
(seasonController.haceLeaves \implies treeprefabWL);
(!seasonController.haveLeaves \implies treeprefabWOL);
(\forall species \implies standardScale := data.species.Height/HSR \wedge lowerBound := 0.9 *
standardScale \wedge upperBound := 1.1 * standardScale);
(\forall species \implies trees.Add(Instantiate(treeprefabs | treeinstance.transform.localscale
= Vector3(randomScale, randomScale, randomScale)))

- output: None
- exception: None

cleanTrees():

- transition: \forall tree \in trees \implies Destroy(tree);
- output: None
- exception: None

28.4.5 Local Functions

calculatedTreeNumbers():

- transition: area := sideLength *sideLength;
(int) treenumbers = $\sum_{species}$ density*area

- output: treenumbers
- exception: None

generateSquareLocation(numberOfPoints):

- transition: `treelocal[i] = Vector3(UnityEngine.Random.Range(startingCoordinate, endingCoordinate), 0f, UnityEngine.Random.Range(startingCoordinate, endingCoordinate))`
- output: None
- exception: None

generateCircleLocation(List<Circle> circles, int numberOfPoints):

- transition: `Point randomPoint := Point(UnityEngine.Random.Range(startingCoordinate, endingCoordinate), UnityEngine.Random.Range(startingCoordinate, endingCoordinate)); (isPointInCircle \implies treelocal[i] = Vector3((float)randomPoint.getX(), 0f, (float) randomPoint.getY());)`
- output: None
- exception: None

isPointInCircles(List< Circle > circles, Point point):

- transition: None
- output: $(\exists \text{ circle} \in \text{circles} \mid \text{circle.isIn}(\text{point}) = \text{true})$
- exception: None

29 MIS of Tree Switch Button Controller(M24)

29.1 Module

TreeSwitchButtonController

29.2 Uses

UnityEngine
UnityEngine.UI

29.3 Syntax

29.3.1 Exported Constants

None

29.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick			

29.4 Semantics

29.4.1 State Variables

isActive: Boolean value indicating if the leaf information page is active.

29.4.2 Environment Variables

None

29.4.3 Assumptions

None

29.4.4 Access Routine Semantics

onClick():

- transition: isActive := !isActive
- output: None
- exception: None

29.4.5 Local Functions

None

30 MIS of Pie Chart Button Controller(M25)

30.1 Module

pieChartButtonController

30.2 Uses

UnityEngine
UnityEngine.UI

30.3 Syntax

30.3.1 Exported Constants

None

30.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick			

30.4 Semantics

30.4.1 State Variables

isActive: Boolean value indicating if the pie chart is active.

30.4.2 Environment Variables

None

30.4.3 Assumptions

None

30.4.4 Access Routine Semantics

onClick():

- transition: isActive := !isActive
- output: None
- exception: None

30.4.5 Local Functions

None

31 MIS of Pie Chart Controller(M26)

31.1 Module

pieChartController

31.2 Uses

pieChartButtonController

UnityEngine

UnityEngine.UI

31.3 Syntax

31.3.1 Exported Constants

None

31.3.2 Exported Access Programs

Name	In	Out	Exceptions
ChangeView			
markChart			

31.4 Semantics

31.4.1 State Variables

isActive: Boolean value indicating if the pie chart is active.

31.4.2 Environment Variables

GameObject graph

Image legend

EnvDataDisp

Data and Image for generating pieChart:

DataModel data

Image regPinePortion

Image oakPortion

Image beechPortion

Image birchPortion

Image redMaplePortion

Image whitePinePortion

Image redOakPortion

GameObject parentObject

31.4.3 Assumptions

None

31.4.4 Access Routine Semantics

ChangeView():

- transition: $\text{graph.gameObejct.SetActive(!isActive)} \wedge \text{legend.gameObject.SetActive(!isActive)} \wedge \text{EnvDataDisp.gameObject.SetActive(isActive)};$
isActive := !isActive
- output: None
- exception: None

markChart():

- transition: calculateValues();
setImagePortions()
- output: None
- exception: None

31.4.5 Local Functions

calculateValues():

- transition: $\text{percentage}_{species} := \text{number}_{species} / \sum_{all species} \text{number}$
- output: None
- exception: None

setImagePortions():

- transition: $\text{pos} := \text{Vector3}(150f, 200f, 0f);$
 $\text{size} := \text{Vector2}(600f, 600f);$
 $\forall \text{species} \implies (\text{Portion}_{species}.\text{transform.localPosition} := \text{pos}$
 $\wedge \text{Portion}_{species}.\text{rectTransform.sizeData} := \text{size}$
 $\wedge \text{Portion}_{species}.\text{fillAmount} := \text{percentage}_{species}$
 $\wedge \text{Portion}_{species}.\text{transform.rotation} := \text{Quaternion.Euler}(\text{Vector3}(0f, 0f, \text{totalRot}))$
 $\wedge \text{totalRot} := \text{totalRot}(\text{percentage}_{species}))$

- output: None
- exception: None

32 MIS of Season Change Button Controller(M27)

32.1 Module

SeasonChangeButtonController

32.2 Uses

32.3 Syntax

32.3.1 Exported Constants

None

32.3.2 Exported Access Programs

Name	In	Out	Exceptions
onClick			

32.4 Semantics

32.4.1 State Variables

isActive: Boolean value indicating if the current season is summer.

32.4.2 Environment Variables

None

32.4.3 Assumptions

None

32.4.4 Access Routine Semantics

onClick():

- transition: isActive := !isActive
- output: None
- exception: None

32.4.5 Local Functions

None

33 MIS of Tree Switch Controller(M28)

33.1 Module

TreeSwitchController

33.2 Uses

UnityEngine

UnityEngine.UI

TreeSwitchButtonController

33.3 Syntax

33.3.1 Exported Constants

None

33.3.2 Exported Access Programs

Name	In	Out	Exceptions
ChangeView			

33.4 Semantics

33.4.1 State Variables

isActive: Boolean value indicating if leaf information is active.

TreeParamDisplay: UI of Tree parameters display.

LeafInfoDisplay: UI of Leaf information display.

33.4.2 Environment Variables

None

33.4.3 Assumptions

None

33.4.4 Access Routine Semantics

ChangeView():

- transition: $(\text{isActive} \implies (\text{LeafInfoDisplay.gameObject.SetActive(false)} \wedge \text{TreeParamDisplay.gameObject.SetActive(true)});$

$(!isActive \implies (LeafInfoDisplay.gameObject.SetActive(true) \wedge TreeParamDisplay.gameObject.SetActive(true)))$

$isActive := !isActive$

- output: None
- exception: None

33.4.5 Local Functions

None

34 MIS of Forest Trees (M29)

34.1 Module

ForestTrees

34.2 Uses

M32 , M33, M34, M35, M36, M37, M38

34.3 Syntax

34.3.1 Exported Constants

None

34.3.2 Exported Access Programs

Name	In	Out	Exceptions
new ForestTrees		ForestTree	
addTree	GameObject(This is unity built-in type)		
deleteTree			

34.4 Semantics

34.4.1 State Variables

trees : *GameObject*{}

34.4.2 Environment Variables

None

34.4.3 Assumptions

None

34.4.4 Access Routine Semantics

new ForestTrees():

- transition: None
- output: *out* := *self*

- exception: None

addTree(tree):

- transition: $trees := trees \cup tree$
- output: None
- exception: None

DeleteTree(s):

- transition: $\forall tree : GameObject | tree \in trees : tree.destory()$
- output: None
- exception: None

34.4.5 Local Functions

None

35 MIS of Forest Sky (M30)

35.1 Module

SkyBox

35.2 Uses

UnityLightning

35.3 Syntax

35.3.1 Exported Constants

None

35.3.2 Exported Access Programs

Name	In	Out	Exceptions
new ForestSky		ForestSky	
setSkyBox	Unity Texture		

35.4 Semantics

35.4.1 State Variables

None

35.4.2 Environment Variables

SkyTexture: imported picture of the skybox.

35.4.3 Assumptions

Unity only takes valid texture file type as input.

35.4.4 Access Routine Semantics

new ForestSky()

- transition: None
- output: None
- exception: None

SetSkybox(s):

- transition: set the current skybox to the selected texture file.
- output: None
- exception: None

35.4.5 Local Functions

None

36 MIS of Forest Terrain (M31)

36.1 Module

ForestTerrain

36.2 Uses

Unity Terrain Tool

36.3 Syntax

36.3.1 Exported Constants

None

36.3.2 Exported Access Programs

Name	In	Out	Exceptions
new ForestTerrain		ForestTerrain	
setLength	Double		
setWidth	Double		

36.4 Semantics

36.4.1 State Variables

None

36.4.2 Environment Variables

None

36.4.3 Assumptions

None

36.4.4 Access Routine Semantics

new ForestTerrain():

- transition: Create a new terrain in unity using the terrain tool
- output: None

- exception: None

setLength(x):

- transition: set the length of the terrain to be x meters
- output: None
- exception: None

setWidth(x):

- transition: set the width of the terrain to be x meters
- output: None
- exception: None

36.4.5 Local Functions

None

We want to address the following two points regarding creating different modules for different tree types:

- We created different modules for different types of trees because this is necessary when it comes to reading from JSON files by using the newtonsoft parser.
- Also, we deleted the “isValidString” local function here since we will check the validity of the string when users input from the GUI

37 MIS of Red Pine (M32)

37.1 Module

RedPine

37.2 Uses

None

37.3 Syntax

37.3.1 Exported Constants

None

37.3.2 Exported Access Programs

Name	In	Out	Exceptions
new RedPine		RedPine	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

37.4 Semantics

37.4.1 State Variables

Treename : *String*

Density : *String*

DBH : *String*

Height : *String*

Age : *String*

37.4.2 Environment Variables

None

37.4.3 Assumptions

None

37.4.4 Access Routine Semantics

new RedPine():

- transition: *Treename*, *Density*, *DBH*, *Height*, *Age* := “Red Pine”, “”, “”, “”, “”
- output: *out* := *self*
- exception: None

getTreeName():

- transition: None
- output: *out* := *Treename*
- exception: None

setDensity(newDensity):

- transition: *Density* := *newDensity*
- output: None
- exception: None

getDensity():

- transition: None

- output: $out := Density$

- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$

- output: None

- exception: None

getDBH():

- transition: None

- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$

- output: None

- exception: None

getHeight():

- transition: None

- output: $out := Height$

- exception: None

setAge(newAge):

- transition: $Age := newAge$

- output: None

- exception: None

getAge():

- transition: None

- output: $out := Age$

- exception: None

37.4.5 Local Functions

None

38 MIS of Oak (M33)

38.1 Module

Oak

38.2 Uses

None

38.3 Syntax

38.3.1 Exported Constants

None

38.3.2 Exported Access Programs

Name	In	Out	Exceptions
new Oak		Oak	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

38.4 Semantics

38.4.1 State Variables

Treename : String

Density : String

DBH : String

Height : String

Age : String

38.4.2 Environment Variables

None

38.4.3 Assumptions

None

38.4.4 Access Routine Semantics

new Oak():

- transition: $Treename, Density, DBH, Height, Age := \text{"Oak"}, \text{""}, \text{""}, \text{""}, \text{"}"$
- output: $out := self$
- exception: None

getTreeName():

- transition: None
- output: $out := Treename$
- exception: None

setDensity(newDensity):

- transition: $Density := newDensity$
- output: None
- exception: None

getDensity():

- transition: None
- output: $out := Density$
- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$
- output: None
- exception: None

getDBH():

- transition: None
- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$
- output: None
- exception: None

getHeight():

- transition: None
- output: $out := Height$
- exception: None

setAge(newAge):

- transition: $Age := newAge$
- output: None
- exception: None

getAge():

- transition: None
- output: $out := Age$
- exception: None

38.4.5 Local Functions

None

39 MIS of Beech (M34)

39.1 Module

Beech

39.2 Uses

None

39.3 Syntax

39.3.1 Exported Constants

None

39.3.2 Exported Access Programs

Name	In	Out	Exceptions
new Beech		Beech	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

39.4 Semantics

39.4.1 State Variables

Treename : String

Density : String

DBH : String

Height : String

Age : String

39.4.2 Environment Variables

None

39.4.3 Assumptions

None

39.4.4 Access Routine Semantics

new Beech():

- transition: $Treename, Density, DBH, Height, Age := \text{"Beech"}, \text{""}, \text{""}, \text{""}, \text{"}"$
- output: $out := self$
- exception: None

getTreeName():

- transition: None
- output: $out := Treename$
- exception: None

setDensity(newDensity):

- transition: $Density := newDensity$
- output: None
- exception: None

getDensity():

- transition: None
- output: $out := Density$
- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$
- output: None
- exception: None

getDBH():

- transition: None
- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$
- output: None
- exception: None

getHeight():

- transition: None
- output: $out := Height$
- exception: None

setAge(newAge):

- transition: $Age := newAge$
- output: None
- exception: None

getAge():

- transition: None
- output: $out := Age$
- exception: None

39.4.5 Local Functions

None

40 MIS of Birch (M35)

40.1 Module

Birch

40.2 Uses

None

40.3 Syntax

40.3.1 Exported Constants

None

40.3.2 Exported Access Programs

Name	In	Out	Exceptions
new Birch		Birch	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

40.4 Semantics

40.4.1 State Variables

Treename : String

Density : String

DBH : String

Height : String

Age : String

40.4.2 Environment Variables

None

40.4.3 Assumptions

None

40.4.4 Access Routine Semantics

new Birch():

- transition: $Treename, Density, DBH, Height, Age := \text{"Birch"}, \text{""}, \text{""}, \text{""}, \text{"}"$
- output: $out := self$
- exception: None

getTreeName():

- transition: None
- output: $out := Treename$
- exception: None

setDensity(newDensity):

- transition: $Density := newDensity$
- output: None
- exception: None

getDensity():

- transition: None
- output: $out := Density$
- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$
- output: None
- exception: None

getDBH():

- transition: None
- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$
- output: None
- exception: None

getHeight():

- transition: None
- output: $out := Height$
- exception: None

setAge(newAge):

- transition: $Age := newAge$
- output: None
- exception: None

getAge():

- transition: None
- output: $out := Age$
- exception: None

40.4.5 Local Functions

None

41 MIS of White Pine (M36)

41.1 Module

WhitePine

41.2 Uses

None

41.3 Syntax

41.3.1 Exported Constants

None

41.3.2 Exported Access Programs

Name	In	Out	Exceptions
new WhitePine		WhitePine	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

41.4 Semantics

41.4.1 State Variables

Treename : String

Density : String

DBH : String

Height : String

Age : String

41.4.2 Environment Variables

None

41.4.3 Assumptions

None

41.4.4 Access Routine Semantics

new WhitePine():

- transition: $Treename, Density, DBH, Height, Age := \text{"White Pine"}, \text{""}, \text{""}, \text{""}, \text{"}"$
- output: $out := self$
- exception: None

getTreeName():

- transition: None
- output: $out := Treename$
- exception: None

setDensity(newDensity):

- transition: $Density := newDensity$
- output: None
- exception: None

getDensity():

- transition: None
- output: $out := Density$
- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$
- output: None
- exception: None

getDBH():

- transition: None
- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$
- output: None
- exception: None

getHeight():

- transition: None
- output: $out := Height$
- exception: None

setAge(newAge):

- transition: $Age := newAge$
- output: None
- exception: None

getAge():

- transition: None
- output: $out := Age$
- exception: None

41.4.5 Local Functions

None

42 MIS of Red Maple (M37)

42.1 Module

RedMaple

42.2 Uses

None

42.3 Syntax

42.3.1 Exported Constants

None

42.3.2 Exported Access Programs

Name	In	Out	Exceptions
new RedMaple		RedMaple	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

42.4 Semantics

42.4.1 State Variables

Treename : String

Density : String

DBH : String

Height : String

Age : String

42.4.2 Environment Variables

None

42.4.3 Assumptions

None

42.4.4 Access Routine Semantics

new RedMaple():

- transition: $Treename, Density, DBH, Height, Age := \text{"Red Maple", "", "", "", ""}$
- output: $out := self$
- exception: None

getTreeName():

- transition: None
- output: $out := Treename$
- exception: None

setDensity(newDensity):

- transition: $Density := newDensity$
- output: None
- exception: None

getDensity():

- transition: None
- output: $out := Density$
- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$
- output: None
- exception: None

getDBH():

- transition: None
- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$
- output: None
- exception: None

getHeight():

- transition: None
- output: $out := Height$
- exception: None

setAge(newAge):

- transition: $Age := newAge$
- output: None
- exception: None

getAge():

- transition: None
- output: $out := Age$
- exception: None

42.4.5 Local Functions

None

43 MIS of Red Oak (M38)

43.1 Module

RedOak

43.2 Uses

None

43.3 Syntax

43.3.1 Exported Constants

None

43.3.2 Exported Access Programs

Name	In	Out	Exceptions
new RedOak		RedOak	
getTreeName		String	
setDensity	String		
getDensity		String	
setDBH	String		
getDBH		String	
setHeight	String		
getHeight		String	
setAge	String		
getAge		String	

43.4 Semantics

43.4.1 State Variables

Treename : String

Density : String

DBH : String

Height : String

Age : String

43.4.2 Environment Variables

None

43.4.3 Assumptions

None

43.4.4 Access Routine Semantics

new RedOak():

- transition: $Treename, Density, DBH, Height, Age := \text{"Red Oak"}, \text{""}, \text{""}, \text{""}, \text{"}"$
- output: $out := self$
- exception: None

getTreeName():

- transition: None
- output: $out := Treename$
- exception: None

setDensity(newDensity):

- transition: $Density := newDensity$
- output: None
- exception: None

getDensity():

- transition: None
- output: $out := Density$
- exception: None

setDBH(newDBH):

- transition: $DBH := newDBH$
- output: None
- exception: None

getDBH():

- transition: None
- output: $out := DBH$

- exception: None

setHeight(newHeight):

- transition: $Height := newHeight$
- output: None
- exception: None

getHeight():

- transition: None
- output: $out := Height$
- exception: None

setAge(newAge):

- transition: $Age := newAge$
- output: None
- exception: None

getAge():

- transition: None
- output: $out := Age$
- exception: None

43.4.5 Local Functions

None

We deleted “isValidString” local function here because we will check the validity of string when users enter data from the GUI

44 MIS of Environmental Data (M39)

44.1 Module

EnvData

44.2 Uses

None

44.3 Syntax

44.3.1 Exported Constants

None

44.3.2 Exported Access Programs

Name	In	Out	Exceptions
new EnvData		EnvData	
setHumidity	String		
getHumidity		String	
setTemp	String		
getTemp		String	
setSC	String		
getSC		String	
setSN	String		
getSN		String	
setLAI	String		
getLAI		String	

44.4 Semantics

44.4.1 State Variables

Humidity : String

Temp : String

SC : String

SN : String

LAI : String

44.4.2 Environment Variables

None

44.4.3 Assumptions

None

44.4.4 Access Routine Semantics

new EnvData():

- transition: $Humidity, Temp, SC, SN, LAI := "", "", "", "", ""$
- output: $out := self$
- exception: None

getHumidity():

- transition: None
- output: $out := Humidity$
- exception: None

setHumidity(newHumidity):

- transition: $Humidity := newHumidity$
- output: None
- exception: None

getTemp():

- transition: None
- output: $out := Temp$
- exception: None

setTemp(newTemp):

- transition: $Temp := newTemp$
- output: None
- exception: None

getSC():

- transition: None
- output: $out := SC$
- exception: None

setSC(newSC):

- transition: $SC := newSC$
- output: None
- exception: None

getSN():

- transition: None
- output: $out := SN$
- exception: None

setSN(newSN):

- transition: $SN := newSN$
- output: None
- exception: None

getLAI():

- transition: None
- output: $out := LAI$
- exception: None

setLAI(newLAI):

- transition: $LAI := newLAI$
- output: None
- exception: None

44.4.5 Local Functions

None

45 MIS of Plot Data (M40)

45.1 Module

PlotData

45.2 Uses

M32, M33, M34, M35, M36, M37, M38, M39

45.3 Syntax

45.3.1 Exported Constants

None

45.3.2 Exported Access Programs

Name	In	Out	Exceptions
new PlotData		PlotData	
setRedPineObj	RedPine		
getRedPineObj		RedPine	
setOakObj	Oak		
getOakObj		Oak	
setBeechObj	Beech		
getBeechObj		Beech	
setBirchObj	Birch		
getBirchObj		Birch	
setWhitePineObj	WhitePine		
getWhitePineObj		WhitePine	
setRedMapleObj	RedMaple		
getRedMapleObj		RedMaple	
setRedOakObj	RedOak		
getRedOakObj		RedOak	
setEnvDataObj	EnvData		
getEnvDataObj		EnvData	

45.4 Semantics

45.4.1 State Variables

RedPineObj : *RedPine*
OakObj : *Oak*
BeechObj : *Beech*
BirchObj : *Birch*
WhitePineObj : *WhitePine*
RedMapleObj : *RedMaple*
RedOakObj : *RedOak*
EnvDataObj : *EnvData*

45.4.2 Environment Variables

None

45.4.3 Assumptions

None

45.4.4 Access Routine Semantics

new PlotData():

- transition:
 - *RedPineObj*, *OakObj*, *BeechObj*, *BirchObj* := *null*, *null*, *null*, *null*
 - *WhitePineObj*, *RedMapleObj*, *RedOakObj*, *EnvDataObj* := *null*, *null*, *null*, *null*
- output: *out* := *self*
- exception: None

getRedPineObj():

- transition: None
- output: *out* := *RedPineObj*
- exception: None

setRedPineObj(newRedPineObj):

- transition: *RedPineObj* := *newRedPineObj*
- output: None

- exception: None

getOakObj():

- transition: None
- output: $out := OakObj$
- exception: None

setOakObj(newOakObj):

- transition: $OakObj := newOakObj$
- output: None
- exception: None

getBeechObj():

- transition: None
- output: $out := BeechObj$
- exception: None

setBeechObj(newBeechObj):

- transition: $BeechObj := newBeechObj$
- output: None
- exception: None

getBirchObj():

- transition: None
- output: $out := BirchObj$
- exception: None

setBirchObj(newBirchObj):

- transition: $BirchObj := newBirchObj$
- output: None
- exception: None

getWhitePineObj():

- transition: None
- output: $out := WhitePineObj$
- exception: None

setWhitePineObj(newWhitePineObj):

- transition: $WhitePineObj := newWhitePineObj$
- output: None
- exception: None

getRedMapleObj():

- transition: None
- output: $out := RedMapleObj$
- exception: None

setRedMapleObj(newRedMapleObj):

- transition: $RedMapleObj := newRedMapleObj$
- output: None
- exception: None

getRedOakObj():

- transition: None
- output: $out := RedOakObj$
- exception: None

setRedOakObj(newRedOakObj):

- transition: $RedOakObj := newRedOakObj$
- output: None
- exception: None

getEnvDataObj():

- transition: None
- output: $out := EnvDataObj$

- exception: None

setEnvDataObj(newEnvDataObj):

- transition: *EnvDataObj* := *newEnvDataObj*
- output: None
- exception: None

45.4.5 Local Functions

None

46 MIS of First Person Player (M41)

46.1 Module

FirstPersonPlayer

46.2 Uses

Character Controller Module from Unity

46.3 Syntax

This is a module provided by UnityEngine.UI. Please click [here](#) to check official document from Unity. We have designed a controller for this module. The controller is PlayerMovement(M4).

46.4 Semantics

This is a module provided by UnityEngine.UI. Please click [here](#) to check official document from Unity. We have designed a controller for this module. The controller is PlayerMovement(M4).

47 MIS of Json File (M42)

47.1 Module

JsonFile. This is not a typical class. This section only aims to show how JSON files are organized formally.

47.2 Local Type

$X = \text{tuple}(\text{key} : \text{String}, \text{value} : \text{String}) \wedge \text{isValidString}(\text{value})$

$S : \text{set of } X$

$\text{TreeANDEnvData} = \text{tuple}(\text{key} : \text{String}, \text{values} : S)$

47.3 State Variables

$\text{JsonFile} : \text{set of TreeANDEnvData}$

47.4 Example

- First, define all the tuples that have type X .

- $x_1 = (\text{"DBH"}, \text{"10"}) : X$
- $x_2 = (\text{"Age"}, \text{"10"}) : X$
- $x_3 = (\text{"Height"}, \text{"10"}) : X$
- $x_4 = (\text{"Density"}, \text{"10"}) : X$

- $x_5 = (\text{"DBH"}, \text{"20"}) : X$
- $x_6 = (\text{"Age"}, \text{"20"}) : X$
- $x_7 = (\text{"Height"}, \text{"20"}) : X$
- $x_8 = (\text{"Density"}, \text{"20"}) : X$

- $x_9 = (\text{"DBH"}, \text{"30"}) : X$
- $x_{10} = (\text{"Age"}, \text{"30"}) : X$
- $x_{11} = (\text{"Height"}, \text{"30"}) : X$
- $x_{12} = (\text{"Density"}, \text{"30"}) : X$

- $x_{13} = (\text{"DBH"}, \text{"40"}) : X$
- $x_{14} = (\text{"Age"}, \text{"40"}) : X$
- $x_{15} = (\text{"Height"}, \text{"40"}) : X$

- $x_{16} = (\text{"Density"}, \text{"40"}) : X$
- $x_{17} = (\text{"DBH"}, \text{"50"}) : X$
- $x_{18} = (\text{"Age"}, \text{"50"}) : X$
- $x_{19} = (\text{"Height"}, \text{"50"}) : X$
- $x_{20} = (\text{"Density"}, \text{"50"}) : X$
- $x_{21} = (\text{"DBH"}, \text{"60"}) : X$
- $x_{22} = (\text{"Age"}, \text{"60"}) : X$
- $x_{23} = (\text{"Height"}, \text{"60"}) : X$
- $x_{24} = (\text{"Density"}, \text{"60"}) : X$
- $x_{25} = (\text{"DBH"}, \text{"70"}) : X$
- $x_{26} = (\text{"Age"}, \text{"70"}) : X$
- $x_{27} = (\text{"Height"}, \text{"70"}) : X$
- $x_{28} = (\text{"Density"}, \text{"70"}) : X$
- $x_{29} = (\text{"Humidity"}, \text{"10"}) : X$
- $x_{30} = (\text{"Temperature"}, \text{"20"}) : X$
- $x_{31} = (\text{"SC"}, \text{"10"}) : X$
- $x_{32} = (\text{"SN"}, \text{"95"}) : X$
- $x_{33} = (\text{"LAI"}, \text{"95"}) : X$

- Second, define all the sets that have type S

- $s_1 = \{x_1, x_2, x_3, x_4\} : S$
- $s_2 = \{x_5, x_6, x_7, x_8\} : S$
- $s_3 = \{x_9, x_{10}, x_{11}, x_{12}\} : S$
- $s_4 = \{x_{13}, x_{14}, x_{15}, x_{16}\} : S$
- $s_5 = \{x_{17}, x_{18}, x_{19}, x_{20}\} : S$
- $s_6 = \{x_{21}, x_{22}, x_{23}, x_{24}\} : S$
- $s_7 = \{x_{25}, x_{26}, x_{27}, x_{28}\} : S$
- $s_8 = \{x_{29}, x_{30}, x_{31}, x_{32}, x_{33}\} : S$

- Third, define all the tuples that have type $TreeANDEnvData$.

- $d_1 = ("RedPineData", s_1) : TreeANDEnvData$
- $d_2 = ("OakData", s_2) : TreeANDEnvData$
- $d_3 = ("BeechData", s_3) : TreeANDEnvData$
- $d_4 = ("BirchData", s_4) : TreeANDEnvData$
- $d_5 = ("WhitePineData", s_5) : TreeANDEnvData$
- $d_6 = ("RedMapleData", s_6) : TreeANDEnvData$
- $d_7 = ("RedOakData", s_7) : TreeANDEnvData$
- $d_8 = ("EnvData", s_8) : TreeANDEnvData$

- Finally, $JsonFile = \{d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8\}$.

47.5 Local Functions

$ValidCharacters = \{ "1", "2", "3", "4", "5", "6", "7", "8", "9", "0", "." \}$

$isValidString(S) : String \rightarrow \mathbb{B}$

$isValidString(S) = \forall (i : \mathbb{Z} | 0 \leq i < |S| : S[i] \in ValidCharacters)$

48 MIS of Main Page (M43)

48.1 Module

MainPageDisplay

48.2 Uses

M6 , M7, M8, M9, M10, M44, M45, M46, M47 UnityEngine.UI

48.3 Syntax

48.3.1 Exported Constants

None

48.3.2 Exported Access Programs

None

48.4 Semantics

This module is used to display the UI of the homepage. You can refer to Unity Canvas Documentation by clicking [here](#).

48.4.1 State Variables

None

48.4.2 Environment Variables

None

48.4.3 Assumptions

None

48.4.4 Access Routine Semantics

None

48.4.5 Local Functions

None

49 MIS of Start Button (M44)

49.1 Module

StartButton

49.2 Uses

M6 , UnityEngine.UI

49.3 Syntax

49.3.1 Exported Constants

None

49.3.2 Exported Access Programs

None

49.4 Semantics

This module is used to display the UI of the StartButton. You can refer to Unity Button Documentation by clicking [here](#).

49.4.1 State Variables

None

49.4.2 Environment Variables

windows: Computer screen used to display messages.

49.4.3 Assumptions

None

49.4.4 Access Routine Semantics

None

49.4.5 Local Functions

None

50 MIS of Instruction Button (M45)

50.1 Module

InstructionButton

50.2 Uses

M7 , UnityEngine.UI

50.3 Syntax

50.3.1 Exported Constants

None

50.3.2 Exported Access Programs

None

50.4 Semantics

This module is used to display the UI of the InstructionButton. You can refer to Unity Button Documentation by clicking [here](#).

50.4.1 State Variables

None

50.4.2 Environment Variables

windows: Computer screen used to display messages.

50.4.3 Assumptions

None

50.4.4 Access Routine Semantics

None

50.4.5 Local Functions

None

51 MIS of Contact Us Button (M46)

51.1 Module

ContactUsButton

51.2 Uses

M8 , UnityEngine.UI

51.3 Syntax

51.3.1 Exported Constants

None

51.3.2 Exported Access Programs

None

51.4 Semantics

This module is used to display the UI of the ContactUsButton. You can refer to Unity Button Documentation by clicking [here](#).

51.4.1 State Variables

None

51.4.2 Environment Variables

windows: Computer screen used to display messages.

51.4.3 Assumptions

None

51.4.4 Access Routine Semantics

None

51.4.5 Local Functions

None

52 MIS of Quit Button (M47)

52.1 Module

QuitButton

52.2 Uses

M10 ,UnityEngine.UI

52.3 Syntax

52.3.1 Exported Constants

None

52.3.2 Exported Access Programs

None

52.4 Semantics

This module is used to display the UI of the QuitButton.You can refer to Unity Button Documentation by clicking [here](#).

52.4.1 State Variables

None

52.4.2 Environment Variables

windows: Computer screen used to display messages.

52.4.3 Assumptions

None

52.4.4 Access Routine Semantics

None

52.4.5 Local Functions

None

53 MIS of Instruction Page (M48)

53.1 Module

InstructionInfoDisplay

53.2 Uses

M7 , UnityEngine.UI

53.3 Syntax

53.3.1 Exported Constants

None

53.3.2 Exported Access Programs

None

53.4 Semantics

This module is used to display the UI of the instruction page. You can refer to Unity Canvas Documentation by clicking [here](#).

53.4.1 State Variables

None

53.4.2 Environment Variables

windows: Computer screen used to display messages.

53.4.3 Assumptions

None

53.4.4 Access Routine Semantics

None

53.4.5 Local Functions

None

54 MIS of Contact Us Page (M49)

54.1 Module

ContactUsInfoDisplay

54.2 Uses

M9 UnityEngine.UI

54.3 Syntax

54.3.1 Exported Constants

None

54.3.2 Exported Access Programs

None

54.4 Semantics

This module is used to display the UI of the Contact Us page. You can refer to Unity Canvas Documentation by clicking [here](#).

54.4.1 State Variables

None

54.4.2 Environment Variables

windows: Computer screen used to display messages.

54.4.3 Assumptions

None

54.4.4 Access Routine Semantics

None

54.4.5 Local Functions

None

55 MIS of Back Button (M50)

55.1 Module

BackButton

55.2 Uses

M11 , UnityEngine.UI

55.3 Syntax

55.3.1 Exported Constants

None

55.3.2 Exported Access Programs

None

55.4 Semantics

This module is used to display the UI of the BackButton. You can refer to Unity Button Documentation by clicking [here](#).

55.4.1 State Variables

None

55.4.2 Environment Variables

windows: Computer screen used to display messages.

55.4.3 Assumptions

None

55.4.4 Access Routine Semantics

None

55.4.5 Local Functions

None

56 MIS of Update Data Page (M51)

56.1 Module

UpdateDataDisplay

56.2 Uses

M8 UnityEngine.UI

56.3 Syntax

56.3.1 Exported Constants

None

56.3.2 Exported Access Programs

None

56.4 Semantics

This module is used to display the UI of the Update Data page. You can refer to Unity Canvas Documentation by clicking [here](#).

56.4.1 State Variables

None

56.4.2 Environment Variables

windows: Computer screen used to display messages.

56.4.3 Assumptions

None

56.4.4 Access Routine Semantics

None

56.4.5 Local Functions

None

57 MIS of Environmental Data Selection Button (M52)

57.1 Module

EnvDataSelectionButton

57.2 Uses

M16 , UnityEngine.UI

57.3 Syntax

57.3.1 Exported Constants

None

57.3.2 Exported Access Programs

None

57.4 Semantics

This module is used to display the UI of the EnvDataSelectionButton. You can refer to Unity Button Documentation by clicking [here](#).

57.4.1 State Variables

None

57.4.2 Environment Variables

windows: Computer screen used to display messages.

57.4.3 Assumptions

None

57.4.4 Access Routine Semantics

None

57.4.5 Local Functions

None

58 MIS of Data Type Selection Button (M53)

58.1 Module

DataTypeSelectionButton

58.2 Uses

M17 , UnityEngine.UI

58.3 Syntax

58.3.1 Exported Constants

None

58.3.2 Exported Access Programs

None

58.4 Semantics

This module is used to display the UI of the DataTypeSelectionButton. You can refer to Unity Button Documentation by clicking [here](#).

58.4.1 State Variables

None

58.4.2 Environment Variables

windows: Computer screen used to display messages.

58.4.3 Assumptions

None

58.4.4 Access Routine Semantics

None

58.4.5 Local Functions

None

59 MIS of New Data Input Box (M54)

59.1 Module

NewDataInputBox

59.2 Uses

, UnityEngine.UI

59.3 Syntax

59.3.1 Exported Constants

None

59.3.2 Exported Access Programs

None

59.4 Semantics

This module is used to display the UI of the new data input box. You can refer to Unity Input Field Documentation by clicking [here](#)

59.4.1 State Variables

None

59.4.2 Environment Variables

windows: Computer screen used to display messages.

59.4.3 Assumptions

None

59.4.4 Access Routine Semantics

None

59.4.5 Local Functions

None

60 MIS of Save Button (M55)

60.1 Module

SaveButton

60.2 Uses

M18 , UnityEngine.UI

60.3 Syntax

60.3.1 Exported Constants

None

60.3.2 Exported Access Programs

None

60.4 Semantics

This module is used to display the UI of the SaveButton.You can refer to Unity Button Documentation by clicking [here](#).

60.4.1 State Variables

None

60.4.2 Environment Variables

windows: Computer screen used to display messages.

60.4.3 Assumptions

None

60.4.4 Access Routine Semantics

None

60.4.5 Local Functions

None

61 MIS of Current Data Display (M56)

61.1 Module

CurrentDataDisplay

61.2 Uses

UnityEngine.UI

61.3 Syntax

61.3.1 Exported Constants

None

61.3.2 Exported Access Programs

None

61.4 Semantics

This module is used to display the UI of the current data. You can refer to Unity Text Documentation by clicking [here](#).

61.4.1 State Variables

None

61.4.2 Environment Variables

windows: Computer screen used to display messages.

61.4.3 Assumptions

None

61.4.4 Access Routine Semantics

None

61.4.5 Local Functions

None

62 MIS of Plot Selection Drop Down (M57)

62.1 Module

PlotSelection

62.2 Uses

M12, UnityEngine.UI

62.3 Syntax

62.3.1 Exported Constants

None

62.3.2 Exported Access Programs

None

62.4 Semantics

This module is used to display the dropdown box of plot selection. You can refer to Unity Drop Down Documentation by clicking [here](#).

62.4.1 State Variables

None

62.4.2 Environment Variables

windows: Computer screen used to display messages.

62.4.3 Assumptions

None

62.4.4 Access Routine Semantics

None

62.4.5 Local Functions

None

63 MIS of Tree Type Selection Drop Down (M58)

63.1 Module

TreeTypeSelection

63.2 Uses

M13 , UnityEngine.UI

63.3 Syntax

63.3.1 Exported Constants

None

63.3.2 Exported Access Programs

None

63.4 Semantics

This module is used to display the dropdown box of the tree type selection. You can refer to Unity Drop Down Documentation by clicking [here](#).

63.4.1 State Variables

None

63.4.2 Environment Variables

windows: Computer screen used to display messages.

63.4.3 Assumptions

None

63.4.4 Access Routine Semantics

None

63.4.5 Local Functions

None

64 MIS of Update Data Button (M59)

64.1 Module

UpdateDataButton

64.2 Uses

M8 , UnityEngine.UI

64.3 Syntax

64.3.1 Exported Constants

None

64.3.2 Exported Access Programs

None

64.4 Semantics

The module is used to display the UI of UpdateDataButton. You can refer to Unity Button Documentation by clicking [here](#).

64.4.1 State Variables

None

64.4.2 Environment Variables

windows: Computer screen used to display messages.

64.4.3 Assumptions

None

64.4.4 Access Routine Semantics

None

64.4.5 Local Functions

None

65 MIS of Forest Display (M60)

65.1 Module

ForestDisplay

65.2 Uses

UnityEngine.UI, M29, M30, M31

65.3 Syntax

65.3.1 Exported Constants

None

65.3.2 Exported Access Programs

None

65.4 Semantics

65.4.1 State Variables

This module is used to display the forest models.

65.4.2 Environment Variables

windows: Computer screen used to display messages.

65.4.3 Assumptions

None

65.4.4 Access Routine Semantics

None

65.4.5 Local Functions

None

66 MIS of Show Environmental Data Button (M61)

66.1 Module

ShowEnvDataButton

66.2 Uses

M14 , UnityEngine.UI

66.3 Syntax

66.3.1 Exported Constants

None

66.3.2 Exported Access Programs

None

66.4 Semantics

This module is used to display the UI of the ShowEnvDataButton. You can refer to Unity Button Documentation by clicking [here](#).

66.4.1 State Variables

None

66.4.2 Environment Variables

windows: Computer screen used to display messages.

66.4.3 Assumptions

None

66.4.4 Access Routine Semantics

None

66.4.5 Local Functions

None

67 MIS of Show Tree Parameters Button (M62)

67.1 Module

ShowTreeParamButton

67.2 Uses

M15 , UnityEngine.UI

67.3 Syntax

67.3.1 Exported Constants

None

67.3.2 Exported Access Programs

None

67.4 Semantics

This module is used to display the UI of the ShowTreeParamButton. You can refer to Unity Button Documentation by clicking [here](#).

67.4.1 State Variables

None

67.4.2 Environment Variables

windows: Computer screen used to display messages.

67.4.3 Assumptions

None

67.4.4 Access Routine Semantics

None

67.4.5 Local Functions

None

68 MIS of Environment Data Display (M63)

68.1 Module

EnvDataDisplay

68.2 Uses

UnityEngine.UI

68.3 Syntax

68.3.1 Exported Constants

None

68.3.2 Exported Access Programs

None

68.4 Semantics

This module is used to display the UI of the environment data. You can check Unity Text Documentation by clicking [here](#).

68.4.1 State Variables

None

68.4.2 Environment Variables

windows: Computer screen used to display messages.

68.4.3 Assumptions

None

68.4.4 Access Routine Semantics

None

68.4.5 Local Functions

None

69 MIS of Tree Parameters Display (M64)

69.1 Module

TreeParamDisplay

69.2 Uses

UnityEngine.UI

69.3 Syntax

69.3.1 Exported Constants

None

69.3.2 Exported Access Programs

None

69.4 Semantics

This module is used to display the UI of the tree parameters. You can check Unity Text Documentation by clicking [here](#).

69.4.1 State Variables

None

69.4.2 Environment Variables

windows: Computer screen used to display messages.

69.4.3 Assumptions

None

69.4.4 Access Routine Semantics

None

69.4.5 Local Functions

None

70 MIS of Pause Indicator (M65)

70.1 Module

PauseIndicatorDisplay

70.2 Uses

UnityEngine.UI

70.3 Syntax

70.3.1 Exported Constants

None

70.3.2 Exported Access Programs

None

70.4 Semantics

This module is used to display the status of pausing. You can check Unity Text Documentation by clicking [here](#).

70.4.1 State Variables

None

70.4.2 Environment Variables

windows: Computer screen used to display messages.

70.4.3 Assumptions

None

70.4.4 Access Routine Semantics

None

70.4.5 Local Functions

None

71 MIS of SeasonChangeButton (M66)

71.1 Module

SeasonChangeButton

71.2 Uses

UnityEngine.UI , M27

71.3 Syntax

71.3.1 Exported Constants

None

71.3.2 Exported Access Programs

None

71.4 Semantics

This module is used to display the seasonal change of the models of the forest

71.4.1 State Variables

None

71.4.2 Environment Variables

windows: Computer screen used to display messages.

71.4.3 Assumptions

None

71.4.4 Access Routine Semantics

None

71.4.5 Local Functions

None

72 MIS of pieChartButton (M67)

72.1 Module

pieChartButton

72.2 Uses

UnityEngine.UI

72.3 Syntax

72.3.1 Exported Constants

None

72.3.2 Exported Access Programs

None

72.4 Semantics

This module is providing a button GUI for users to switch between a pie chart and environmental data.

72.4.1 State Variables

None

72.4.2 Environment Variables

windows: Computer screen used to display messages.

72.4.3 Assumptions

None

72.4.4 Access Routine Semantics

None

72.4.5 Local Functions

None

73 MIS of TreeSwitchButton (M68)

73.1 Module

TreeSwitchButton

73.2 Uses

UnityEngine.UI

73.3 Syntax

73.3.1 Exported Constants

None

73.3.2 Exported Access Programs

None

73.4 Semantics

This module provides a button GUI for users to switch between tree parameters and leaf information

73.4.1 State Variables

None

73.4.2 Environment Variables

windows: Computer screen used to display messages.

73.4.3 Assumptions

None

73.4.4 Access Routine Semantics

None

73.4.5 Local Functions

None

References

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