

Module Interface Specification for Breaking Effect

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December 6, 2017

1 Revision History

| Date | Version | Notes |
|-----------------|---------|---------|
| Date 2017-11-17 | 1.0 | New doc |

2 Symbols, Abbreviations and Acronyms

See SRS Documentation at <https://github.com/MaXiaoye/cas741/blob/master/Doc/SRS/SRS.pdf>

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3 Introduction

The following document details the Module Interface Specifications for Breaking Effect.

Breaking effect presents how the pieces of an object move after it separates into parts with suddenness or violence.

This project implements running time breaking effect in codes for 3-D models in unity3D without help from any similar plug-in. Including different shapes 3-D objects breaking based on physics and pieces interacting with the momentum provided by the breaking force. The breaking effect program simulates 3-D objects destruction process in vision by implementing scientific computing functions.

This project concentrates on calculation while HCI or GUI are not important parts. Applied force is decided in codes in advance as input and trace of motion is the output after calculation.

Complementary documents include the System Requirement Specifications and Module Guide. The full documentation and implementation can be found at <https://github.com/MaXiaoye/cas741>.

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 Program Name.

| Data Type | Notation | Description |
|----------------|--------------|---|
| natural number | \mathbb{N} | a number without a fractional component in $[1, \infty)$ |
| real | \mathbb{R} | any number in $(-\infty, \infty)$ |
| String | String | represents sequences of characters. |
| Object | Object | A data structure to store attributes of input target object that provided by Unity3D. |
| PieceObject | PieceObj | A data structure to store attributes of pieces that generated as intermediate steps. |

The specification of Program Name 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, Program

Name 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

The following table is taken directly from the Module Guide document for this project.

| Level 1 | Level 2 |
|--------------------------|--|
| Hardware-Hiding Module | |
| | Input Module |
| | Piece Object Module |
| | Pieces initialization module |
| Behaviour-Hiding Module | Displacement calculation module |
| | |
| Software Decision Module | Target Object Module |
| | Collision with ground detection Module |
| | Output Module |

Table 1: Module Hierarchy

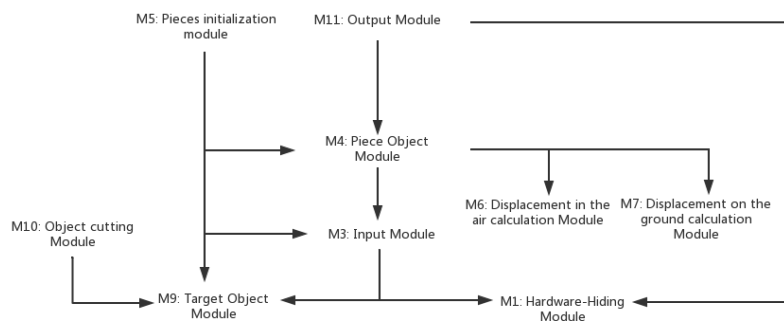


Figure 1: Use hierarchy among modules

6 MIS of Input Module(M3)

This module collect verifies input from user and store in corresponding variables. Include position of target object, explosion level, coefficient of ground friction.

6.1 Module

InputModule

6.2 Uses

Hardware-Hiding Module (M1)

6.3 Syntax

6.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|-----------------|---------------------------|------|--------------|
| μ_k | \mathbb{R} | - | InvalidInput |
| E | \mathbb{R} | - | InvalidInput |
| $TargetObj$ | <i>Object</i> | - | InvalidInput |
| $InputVerify()$ | $\mathbb{R}^2; TargetObj$ | void | InvalidInput |

[Object is a 3D model in Unity3D, which contains its position (X, Y, Z) . User needs provide a 3D model and attach the program to it. —Author]

6.4 Semantics

6.4.1 State Variables

None

6.4.2 Access Routine Semantics

$InputVerify()$:

- transition: N/A
- output: Exceptions or None.
- exception:[Different kinds of exceptions for different invalid inputs. —Author]
exc := $(\mu_k = \text{null} \Rightarrow \text{NoMuException})$
exc := $(E = \text{null} \Rightarrow \text{NoELvException})$
exc := $(X \notin \mathbb{R} \vee (X \leq -1000) \vee (X \geq 1000) \Rightarrow \text{InvalidCoorException})$
exc := $(Z \notin \mathbb{R} \vee (Z \leq -1000) \vee (Z \geq 1000) \Rightarrow \text{InvalidCoorException})$

$\text{exc} := (Y! = 0 \Rightarrow \text{InvalidCoorException})$
 $\text{exc} := (E \notin \mathbb{R} \vee (E \leq 0) \vee (E \geq 10) \Rightarrow \text{InvalidELvException})$
 $\text{exc} := (\mu_k \notin \mathbb{R} \vee (\mu_k \leq 0) \vee (\mu_k \geq 1) \Rightarrow \text{InvalidMuException})$

7 MIS of piece object module(M4)

Customize class for pieces. Pieces are generated after explosion happens to replace original target object from input.

7.1 Module

ObjCutModule

7.2 Uses

Input Module(M3)

Displacement in the air calculation Module(M6)

Displacement on the ground calculation Module(M??)

7.3 Syntax

7.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|-----------------|--------------------------------|-----|------------|
| obj | Object | - | - |
| x | \mathbb{R} | - | - |
| y | \mathbb{R} | - | - |
| z | \mathbb{R} | - | - |
| onGround | Boolean | - | - |
| stop | Boolean | - | - |
| θ_1 | \mathbb{R} | - | - |
| θ_2 | \mathbb{R} | - | - |
| initSpeed | \mathbb{R} | - | - |
| speedThisFrameX | \mathbb{R} | - | - |
| speedLastFrameX | \mathbb{R} | - | - |
| speedThisFrameZ | \mathbb{R} | - | - |
| speedLastFrameZ | \mathbb{R} | - | - |
| PieceObj() | \mathbb{R}^2 ; <i>Object</i> | - | - |
| MoveInAir() | - | - | - |
| MoveOnGround() | - | - | - |
| Translate() | \mathbb{R}^3 | - | - |

- obj is the 3D model of PieceObj in scene.
- x, y, z are coordinates of object.
- onGround indicates if the object is on the ground.
- stop indicates if the speed of object already equals to 0.
- θ_1 is the angle between initial speed v_0 and horizontal.
- θ_2 is the angle between x axiom and projection on horizontal of initial speed
- initSpeed is the initial speed the object has when explosion happens.
- PieceObj() is constructor
- Translate() controls motion of the object.
- MoveInAir() and MoveOnGround() controls motion of the object by calling Translate(). It check onGround firstly to make sure the object is in the air or on the ground. Based on value of bool variable onGround, that call and provide corresponding destination as input to Translate(). Destination to Translate() is calculated by M6 and M??.

7.4 Semantics

7.4.1 State Variables

None

7.4.2 Access Routine Semantics

PieceObj(): [use M3 here —Author]

- transition: Initialize PieceObj
- output: None
- exception: None

thetaOneCalc():

Calculate the angle between initial speed v_0 and horizontal θ_1 . [θ_1 and θ_2 are values of each PieceObj —Author]

Equation: $\theta_1 = \arctan \frac{y_n}{\sqrt{(x_n - X)^2 + (z_n - Y)^2}}$

Convert equation to codes:

Mathf.Atan(PieceObj.y / Mathf.Sqrt(Mathf.Pow(PieceObj.x - TargetObj.x,2) + Mathf.Pow(PieceObj.z - TargetObj.z,2)));

- transition: $\theta_1 : null \rightarrow \mathbb{R}$
- output: None
- exception: None

thetaTwoCalc():

Calculate the angle between x axiom and projection on horizontal of initial speed θ_2 .

Equation: $\theta_2 = \arctan \frac{x_n - X}{z_n - Z}$

Convert equation to codes:

Mathf.Atan2(PieceObj.x - TargetObj.x, PieceObj.z - TargetObj.z)

- transition: $\theta_2 : null \rightarrow \mathbb{R}$
- output: None
- exception: None

MoveInAir(): [use M6 here —Author]

- transition: Move PieceObj in the air by updating x, y, z
- output: None
- exception: None

MoveOnGround(): [use M6 here —Author]

- transition: Move PieceObj on the ground by updating x, y, z
- output: None
- exception: None

8 MIS of pieces initialization module (M5)

8.1 Module

PieceInitModule

8.2 Uses

Input Module(M3)

Piece Object Module(M4)

target object module(M8)

8.3 Syntax

8.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|------------|--------------------------------|----------|------------|
| targetObj | - | - | - |
| subObj[] | - | - | - |
| pieceObj[] | - | - | - |
| PieceObj() | \mathbb{R}^2 ; <i>Object</i> | PieceObj | - |

- targetObj is the 3D model of target object in scene.
- subObj[] is a list of sub objects under target Object [Since all pieces make up the whole target object, all pieces object are considered as sub objects of the target object in Unity3D. We need to get all sub objects firstly and then use these sub objects to construct piece objects defined by myself. —Author]
- pieceObj[] is a list of piece objects defined by myself.
- PieceObj() is constructor of piece object that defined in M4. [use M4 here. —Author]

8.4 Semantics

8.4.1 State Variables

None

8.4.2 Access Routine Semantics

Do traversal to initialize all pieces. [Each piece is stored as an instance of class PieceObj defined in M4. Gravity center is position value in PieceObj —Author]

```
targetObj = GameObject.Find("targetObj");
subObj = targetObj.GetComponentInChildren<Transform>();
pieceObj = new PieceObj[targetObj.transform.childCount];
for (int i = 1; i < subObj.Length; i++) pieceObj[i - 1] = new PieceObj(subObj[i].gameObject,
initSpeed, g);
```

9 MIS of Displacement calculation module(M6)

Calculate and output trace of motion for each piece in the air by using follow equations.

9.1 Module

DisAirCalModule

9.2 Uses

Input Module(M3)

9.3 Syntax

9.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|------------|---------------------------------------|--------------|------------|
| DisAirCalX | \mathbb{R} ; PieceObj; TargetObject | \mathbb{R} | - |
| DisAirCalY | \mathbb{R} ; PieceObj; TargetObject | \mathbb{R} | - |
| DisAirCalZ | \mathbb{R} ; PieceObj; TargetObject | \mathbb{R} | - |
| DisGroCalX | \mathbb{R} ; PieceObj; TargetObject | \mathbb{R} | - |
| DisGroCalZ | \mathbb{R} ; PieceObj; TargetObject | \mathbb{R} | - |

9.4 Semantics

9.4.1 State Variables

None

9.4.2 Access Routine Semantics

DisAirCalX():

Equation: $v_0 = 10 * E, S_x = v_0 \cdot \cos\theta_1 \cdot \sin\theta_2 \cdot \Delta t$ [Based on A8 in SRS that value of initial velocity given by explosion is ten times input E unit length in unity per second. Δt is the gap between each frame that input from unity3D —Author]

Convert equation to codes:

initSpeed * Mathf.Cos(PieceObj.theta1) * Mathf.Sin(PieceObj.theta2) * Time.deltaTime

- transition: None
- output: $S_x : \mathbb{R}$
- exception: None

DisAirCalY():

Equation: $S_y = (v_0 \cdot \sin\theta_1 - g \cdot t) \cdot \Delta t - \frac{1}{2}g \cdot \Delta t^2$ [t is real time since the explosion happens. So that $v_0 \cdot \sin\theta_1 - g \cdot t$ means the initial speed on vertical direction at the beginning of each frame —Author]

Convert equation to codes:

$(\text{initSpeed} * \text{Mathf.Sin}(\text{PieceObj.theta1}) + g * \text{Time.realtimeSinceStartup}) * \text{Time.deltaTime}$
 $+ 1 / 2 * g * \text{Time.deltaTime} * \text{Time.deltaTime}$

- transition: None
- output: $S_y : \mathbb{R}$
- exception: None

DisAirCalZ():

Equation: $S_z = v_0 \cdot \cos\theta_1 \cdot \cos\theta_2 \cdot \Delta t$

Convert equation to codes:

$\text{initSpeed} * \text{Mathf.Cos}(\text{PieceObj.theta1}) * \text{Mathf.Cos}(\text{PieceObj.theta2}) * \text{Time.deltaTime}$

- transition: None
- output: $S_z : \mathbb{R}$
- exception: None

DisGroCalX():

Equation: $a = \mu_k g$; $S_x = (v_0 \cdot \cos\theta_1 \cdot \sin\theta_2 - at) \cdot \Delta t - \frac{1}{2}a \cdot \Delta t^2$

Convert equation to codes:

$(\text{initSpeed} * \text{Mathf.Sin}(\text{PieceObj.theta2}) * \text{Mathf.Cos}(\text{PieceObj.theta1}) - a * \text{Time.realtimeSinceStartup})$
 $* \text{Time.deltaTime} - 1 / 2 * a * \text{Time.deltaTime} * \text{Time.deltaTime}$

- transition: None
- output: $S_x : \mathbb{R}$
- exception: None

DisGroCalZ():

Equation: $a = \mu_k g$; $S_z = (v_0 \cdot \cos\theta_1 \cdot \cos\theta_2 - at) \cdot \Delta t - \frac{1}{2}a \cdot \Delta t^2$

Convert equation to codes:

$(\text{initSpeed} * \text{Mathf.Cos}(\text{PieceObj.theta2}) * \text{Mathf.Cos}(\text{PieceObj.theta1}) - a * \text{Time.realtimeSinceStartup})$
 $* \text{Time.deltaTime} - 1 / 2 * a * \text{Time.deltaTime} * \text{Time.deltaTime}$

- transition: None
- output: $S_z : \mathbb{R}$
- exception: None

10 MIS of target object module(M8)

Object class provided by platform

10.1 Module

TarObjModule

10.2 Uses

Input Module(M3)

10.3 Syntax

10.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|-----------|----------------|-----|------------|
| X | \mathbb{R} | - | - |
| Y | \mathbb{R} | - | - |
| Z | \mathbb{R} | - | - |
| position | \mathbb{R}^3 | - | - |
| destory() | - | - | - |

X, Y, Z are coordinates of object. position is 3D vector that contains X, Y, Z while it is also considered as gravity center location of the object, destory() function removes the object.

10.4 Semantics

10.4.1 State Variables

KeyCode.Space: Boolean. This bool value indicates if key space is pressed on keyboard.

10.4.2 Access Routine Semantics

destory():

[We assume the explosion happens when "space" is pressed. The target object is removed from scene at the same time. —Author]

- transition: target object \rightarrow null
- output: None
- exception: None

11 MIS of Collision with ground detection Module (M9)

Detect if there is a collision between a piece and the ground. If so, set onGround value to true.

11.1 Module

ColDetectModule

11.2 Uses

Input Module(M3)

11.3 Syntax

11.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|------------------|----|-----|------------|
| OnTriggerEnter() | - | - | - |

11.4 Semantics

11.4.1 State Variables

onGround

11.4.2 Access Routine Semantics

OnTriggerEnter():

- transition: pieceObj.onGround: false \rightarrow true;
- output: None
- exception: None

12 MIS of Output Module(M10)

Unity3D interface with codes by calling function update() each frame. Unity3D convert data into visualization. Provide free camera for people to control view.

12.1 Module

OutputModule

12.2 Uses

Displacement calculation module(M6)

12.3 Syntax

12.3.1 Exported Access Programs

| Name | In | Out | Exceptions |
|---------------|----------------------------|---------------|------------|
| update() | codes to be run each frame | Visualization | - |
| start() | - | - | - |
| CameraControl | - | - | - |

12.4 Semantics

12.4.1 State Variables

Scene;

12.4.2 Access Routine Semantics

start():

Start is called on the frame when a script is enabled just before any of the Update methods is called the first time.

- transition: Initialization of scene.
- output: None
- exception: None

Fixedupdate():

Fixedupdate is called every frame. In Fixedupdate(), we listen if space is pressed as start point of the explosion. It also keeps updating status of all objects in the scene to convert location of objects to visualization that can be seen on the screen.

- transition: Piece objects \rightarrow Visualization
- output: None
- exception: None

References

- Carlo Ghezzi, Mehdi Jazayeri, and Dino Mandrioli. *Fundamentals of Software Engineering*. Prentice Hall, Upper Saddle River, NJ, USA, 2nd edition, 2003.
- Daniel M. Hoffman and Paul A. Strooper. *Software Design, Automated Testing, and Maintenance: A Practical Approach*. International Thomson Computer Press, New York, NY, USA, 1995. URL <http://citeseer.ist.psu.edu/428727.html>.

13 Appendix