

# Module Interface Specification for Breaking Effect

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November 30, 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>

[Also add any additional symbols, abbreviations or acronyms —SS]

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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                           |
|                          | Obtaining gravity center module               |
| Behaviour-Hiding Module  | Angle calculation module                      |
|                          | Displacement in the air calculation module    |
|                          | Displacement on the ground calculation module |
| Software Decision Module | Target Object Module                          |
|                          | Object cutting module                         |
|                          | Output Module                                 |

Table 1: Module Hierarchy



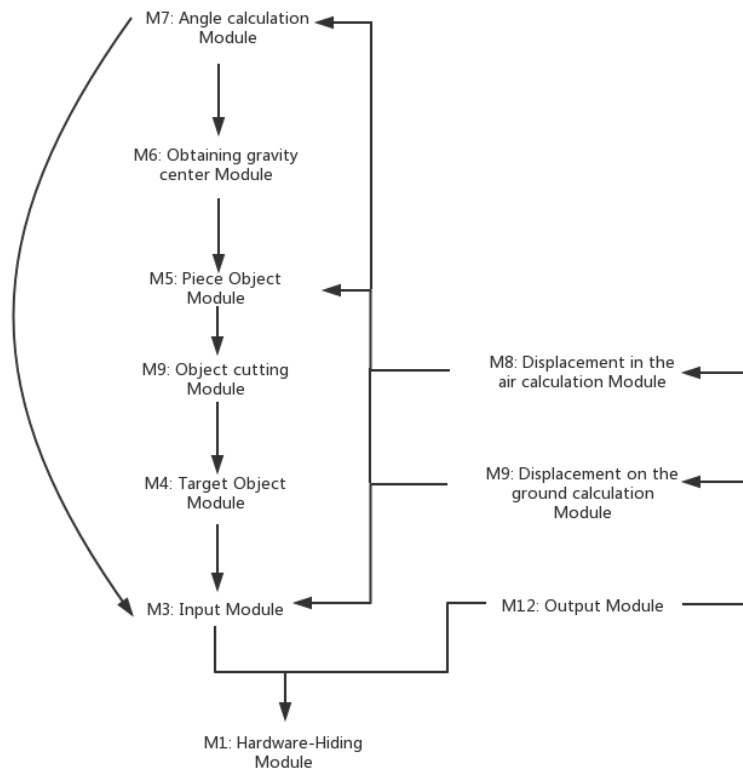


Figure 1: Use hierarchy among modules

## 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   |
|-----------------|---------------------------|------|--------------|
| $\mu_k$         | $\mathbb{R}$              | -    | 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 :=  $(\text{ExplosionLv} = \text{null} \Rightarrow \text{NoELvException})$   
exc :=  $(X, Y, Z \notin \mathbb{R} \vee (X, Y, Z \leq -1000) \vee (X, Y, Z \geq 1000) \Rightarrow \text{InvalidCoorException})$   
exc :=  $(E \notin \mathbb{R} \vee (E \leq 0) \vee (E \geq 10) \Rightarrow \text{InvalidELvException})$   
exc :=  $(\mu_k \notin \mathbb{R} \vee (\mu_k \leq 0) \vee (\mu_k \geq 1) \Rightarrow \text{InvalidMuException})$

## 7 MIS of target object module(M4)

Object class provided by platform

### 7.1 Module

TarObjModule

### 7.2 Uses

Input Module(M3)

### 7.3 Syntax

#### 7.3.1 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.

### 7.4 Semantics

#### 7.4.1 State Variables

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

#### 7.4.2 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

## 8 MIS of piece object module(M5)

Customize class for pieces that extend object class provided by platform. Pieces are generated after explosion happens to replace original target object from input.

### 8.1 Module

ObjCutModule

### 8.2 Uses

Input Module(M3)

### 8.3 Syntax

#### 8.3.1 Exported Access Programs

| Name        | In             | Out           | Exceptions |
|-------------|----------------|---------------|------------|
| Tag         | String         | -             | -          |
| $x$         | $\mathbb{R}$   | -             | -          |
| $y$         | $\mathbb{R}$   | -             | -          |
| $z$         | $\mathbb{R}$   | -             | -          |
| position    | $\mathbb{R}^3$ | -             | -          |
| onGround    | Boolean        | -             | -          |
| $\theta_1$  | $\mathbb{R}$   | -             | -          |
| $\theta_2$  | $\mathbb{R}$   | -             | -          |
| Move()      | Boolean        | -             | -          |
| Translate() | $\mathbb{R}^3$ | Visualization | -          |

Assumptions:

Tag,  $x, y, z$  and position, Translate() are inherited from parent class

- Tag is string "piece" that indicates the object is an instance piece object.
- $x, y, z$  are coordinates of object.
- position is 3D vector that contains  $x, y, z$ .
- Translate() controls motion of the object.
- onGround indicates if the object is on the ground.
- $\theta_1, \theta_2$  are calculated and described in M7.

- Move() 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 M8 and M9.

[The definition of this class doesn't use M8 and M9 while result from M8 and M9 are only passed to function Move() that is called in M12. So I don't put M8 and M9 in Uses part. —Author]

## 8.4 Semantics

### 8.4.1 State Variables

None

### 8.4.2 Access Routine Semantics

Move():

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

Translate():

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

## 9 MIS of acquiring pieces module (M6)

Call cutting function provided by Unity3D to split target object into pieces then do traversal to acquire all pieces. [Each piece is stored as an instance of class piece object defined in M5. Gravity center is position value in PieceObj —Author]

### 9.1 Module

ObtainGCModule

### 9.2 Uses

Input Module(M3)

Object cutting module(M13)

## 9.3 Syntax

### 9.3.1 Exported Access Programs

| Name       | In                     | Out              | Exceptions |
|------------|------------------------|------------------|------------|
| Traverse() | PieceObj; $\mathbb{R}$ | List of PieceObj | -          |

## 9.4 Semantics

### 9.4.1 State Variables

None

### 9.4.2 Access Routine Semantics

Traverse():

This function do a Traverse to store all piece objects into a list by filtering tags with "piece". Piece objects are initialed after target object is cutted. [tags for piece objects are defined in M5 —Author]

- transition: None
- output: List of PieceObj
- exception: None

## 10 MIS of Angle calculation module(M7)

Calculate the angle between initial speed  $v_0$  and horizontal  $\theta_1$ . Calculate the angle between  $x$  axiom and projection on horizontal of initial speed  $\theta_2$ . [ $\theta_1$  and  $\theta_2$  are values of each PieceObj —Author]

### 10.1 Module

AngleCalModule

### 10.2 Uses

Input Module(M3)

Obtaining gravity center module (M6)

## 10.3 Syntax

### 10.3.1 Exported Access Programs

| Name      | In                            | Out          | Exceptions |
|-----------|-------------------------------|--------------|------------|
| AngleSH() | $\mathbb{R}; \text{PieceObj}$ | $\mathbb{R}$ | -          |
| AngleXV() | $\mathbb{R}; \text{PieceObj}$ | $\mathbb{R}$ | -          |

## 10.4 Semantics

### 10.4.1 State Variables

None

### 10.4.2 Access Routine Semantics

AngleSH():

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

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

AngleXV():

Equation:  $\theta_2 = \arctan \frac{|y_n - Y|}{|x_n - X|}$

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

## 11 MIS of Displacement in the air calculation module(M8)

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

### 11.1 Module

DisAirCalModule

## 11.2 Uses

Input Module(M3)

Angle calculation module(M7)

## 11.3 Syntax

### 11.3.1 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 | $\mathbb{R}$ | -          |

## 11.4 Semantics

### 11.4.1 State Variables

None

### 11.4.2 Access Routine Semantics

DisAirCalX():

Equation:  $v_0 = 10 * E, S_x = v_0 \cdot \cos\theta_1 \cdot \cos\theta_2 \cdot t$  [Based on assumption8 in SRS that value of initial velocity given by explosion is ten times input  $E$  unit length in unity per second. —Author]

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

DisAirCalY():

Equation:  $S_y = v_0 \cdot \cos\theta_1 \cdot \sin\theta_2 \cdot t$

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

DisAirCalZ():

Equation:  $S_z = v_0 \cdot \sin\theta_1 \cdot t - \frac{1}{2}gt^2$



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

## 12 MIS of Displacement on the ground calculation module(M9)

Calculate and output trace of motion for each piece on the ground by using follow equations.

### 12.1 Module

DisGroCalModule

### 12.2 Uses

Input Module(M3) Angle calculation module(M7)

### 12.3 Syntax

#### 12.3.1 Exported Access Programs

| Name       | In   | Out          | Exceptions |
|------------|--|--------------|------------|
| DisGroCalX | $\mathbb{R}; \text{ PieceObj; TargetObject}$ | $\mathbb{R}$ | -          |
| DisGroCalY | $\mathbb{R}; \text{ PieceObj; TargetObject}$ | $\mathbb{R}$ | -          |

### 12.4 Semantics

#### 12.4.1 State Variables

None

#### 12.4.2 Access Routine Semantics

DisGroCalX():

Euqation:  $a = \mu_k g; S_x = v_0 \cdot \cos\theta_1 \cdot \cos\theta_2 \cdot t - \frac{1}{2}at^2$

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

DisGroCalY():

Euqation:  $a = \mu_k g$ ;  $S_y = v_0 \cdot \cos\theta_1 \cdot \sin\theta_2 \cdot t - \frac{1}{2}at^2$

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

## 13 MIS of Object cutting Module(M13)

External function provided by platform. Split target object to pieces.

### 13.1 Module

ObjCutModule

### 13.2 Uses

Input Module(M3)

### 13.3 Syntax

#### 13.3.1 Exported Access Programs

| Name  | In        | Out      | Exceptions |
|-------|-----------|----------|------------|
| cut() | TargetObj | PieceObj | -          |

### 13.4 Semantics

#### 13.4.1 State Variables

None

#### 13.4.2 Access Routine Semantics

cut():

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

## 14 MIS of Output Module(M12)

Unity3D interface with codes by calling function update() each frame. Unity3D convert data into visualization.

### 14.1 Module

OutputModule

### 14.2 Uses

Displacement in the air calculation module(M8)

Displacement on the ground calculation module(M9)

### 14.3 Syntax

#### 14.3.1 Exported Access Programs

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

### 14.4 Semantics

#### 14.4.1 State Variables

Screen;  
PieceObj

#### 14.4.2 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: null  $\rightarrow$  target object [target object is initialized in scene —Author]
- output: None
- exception: None

update():

Update is called every frame. In update(), 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>.

## 15 Appendix