Finding Classes by Execution from an Object-Oriented Class Library

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Introduction

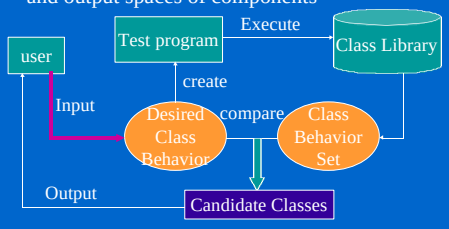
- Software Reuse? Why Reuse ?
- Component Retrieval Approaches
  - Information Retrieval Methods
  - Descriptive Methods
  - Operational Semantic Methods
  - ……..

Introduction

- Steps to organize and retrieve components
  - Organizing the component library
  - Formulating the user query
  - Retrieving components from library
  - Browsing the candidates

Introduction

- Execution-based retrieval?
  - find relevant components by comparing input and output spaces of components



Introduction

- Execution-based retrieval
  - Podgurski & Pierce (1992) proposed behavior retrieval for function components
  - Atkinson & Duke (1995) proposed for OO classes, but without implementation
  - Extended and implemented by Niu (1999)

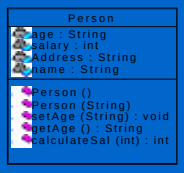
Introduction

- The class library in previous method

```
Public class ObjectEquals{
        public boolean equals (Object arg1, Object arg2) {
                return arg1.equals (arg2);
        }
        public boolean notEquals(Object arg1, Object arg2) {
                return !arg1.equals (arg2);
        }
        public boolean identical(Object arg1, Object arg2) {
                return arg1==arg2;
        }
        public boolean identical(Object arg1, Object arg2) {
                return arg1==arg2;
        }
}
```

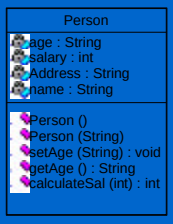
Introduction

- Class only perform math calculations, string manipulations, object comparisons
- Similar to the functions of procedure languages
- Different from the "real world" class



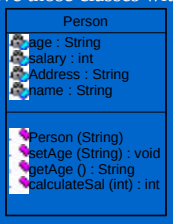
Introduction

- Uncaptureable behavior
  - only method calculateSal (int) can be executed



Introduction

- Default constructor
  - can not retrieve those classes with user-defined constructors



Introduction

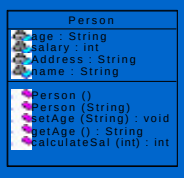
- Order of arguments
  - require user to input the correct argument order
  - This is not practical
  - reduce retrieval recall

Method (String, int, boolean)

```
public class C {
        ……..
        public int add (int, String, boolean) {}
        ……..
}
```

Organize the input program

- Fully consider the "real world" classes
  - Class definition
    - fields
    - constructors
    - observer methods
    - modifier methods



  - Class N={{F}, {C}, {O}, {M})

Organize the input program

Differences among constructor, observer and modifier

Types	Return		Parameters	
	Type	value	Type	value
Constructors	none	none	any	any
Observers	Any (except void)	Any (except none)	none	none
Modifiers	Any (include none)	Any (include none)	any	any

Organize the input program

- Class behavior
  - A set of responses from the class methods based on a test program
  - A complete class behavior is all the responses from all the methods and constructors

Organize the input program

- In order to disclose the complete behavior of a class
  - create an instance (object)
  - update the states (by calling modifier)
  - inspect each state to determine whether it is in the state as expected (by calling observer)

Organize the input program

- Program executing order
  - execute one or more constructors to create some objects with initial states (if no, a default constructor is called)
  - execute zero/more modifier methods to modify the states of the object
  - apply observer methods to the objects.
  - the result returned by the observer are compared with the user's input

  CM*O+

Organize the input program

- Message
  - a set of input values and types
  - desired return type and value
  - the type is determined by the message (constructor, observer, modifier)

  message1{(int, 5), (none, none)}
  message2{(int, 2),(boolean,true),(void, none)}
  message3{(none, none),(int, 2)}

Organize the input program

- Test program
  - A set of messages to be sent to the system

  {[(int, 5)], [(int, 2),(boolean,true)], [(none, none)]}

  with expected behavior {none, none, 2}

Retrieve classes from library

- Type Checking & Run-time storage
  - Store the info during first time

```
For each constructor
   if (it is the first constructor)
            load class from the library
            stored constructor info
   if (arglist==parameterlist)
            execute constructor
   else skip
```

Retrieve classes from library

- Type Checking & Run-time storage

```
For each method
    if (it is the first method)
            load class from the library
            stored method info
    if (arglist==parameterlist && return types matches)
            execute method
    else skip
```

Retrieve classes from library

- Retrieval regardless of argument order
  - message {(int, 5), (String, “li”), (float, 6.0), (none, none)}
    - (int, String, float)
    - (int, float, String)
    - (String, float, int)
    - (String, int, float)
    - (float, String, int)
    - (float, int, String)
  - Recursively execution on these compositions

Retrieve classes from library

- Matching process and candidate classes
  - A match is found, if the message and the method have:
    - the same type (constructor, observer, and modifier)
    - the same number of arguments and convertible types
    - the same or convertible return types
    - the same or tolerable return values

Retrieve classes from library

- Matching process and candidate classes
  - Matching algorithm

```
for each test message
        if (it is constructor)
                if (argument list matches parameterlist
                in each constructor)
                        construct the instance
                        return true
                else   return false
```

Retrieve classes from library

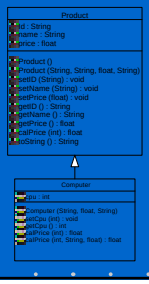
```
Else   //it is method
        if (the return types match)
                if (check each case of argument list
                with parameter list of each method)
                        if (there is no instance)
                                call default constructor
                        executes on the method
                        if (result same as the expected)
                                return true
                return false
        else return false
```

Retrieve classes from library

- Matching process and candidate classes
  - Candidates classes
    - matches info stored in a vector associated with the class name
    - classes with at least 1 match
    - display the candidates (the most match class comes first)

Retrieve classes from library

- Inheritance, Overloading and Overriding
  - Inheritance
    - subclass and superclass
    - inherited methods should be executed and counted if the match is found



Retrieve classes from library

- Inheritance, Overloading and Overriding
  - Overloading
    - Selection of the actual method is based on the type matching between arguments of messages and parameter of methods
    - Do not need to take care specially
  - Overriding
    - overriding method and overridden method
    - overriding method does not cause side effect
    - overridden method is hidden from the subclass

Browse the Candidates

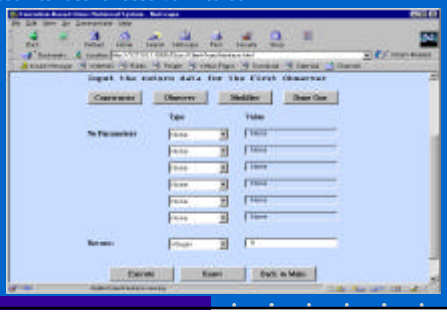
- Directly browse the code (implementation) is practical and useful
  - Class library is small scale
  - Candidate classes are not too many

Implementation

Main Interface

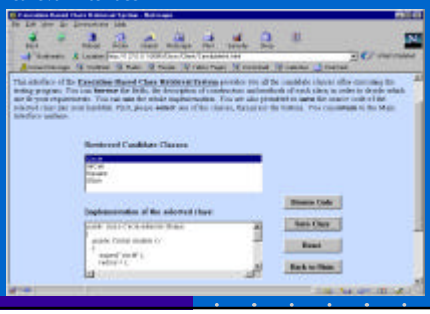
Implementation

Input interface for observer method



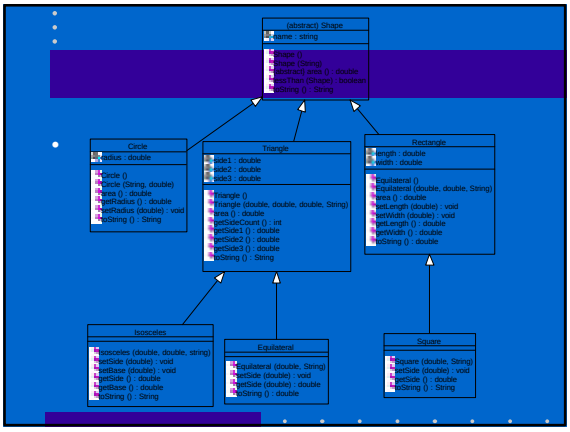
Implementation

Retrieval Interface



An Example of Library

- A class library contains 7 classes
  - Geometry related classes: Shape, Circle, Triangle, Rectangle, Equilateral, Isosceles and Square
  - They are related.



Conclusions

- An execution-based class retrieval method is proposed for OO class library
  - Capturing the complete behavior of a class
  - Considering the OO characteristics (inheritance, overloading and overriding)
- Techniques
  - providing user-defined constructors
  - neglecting argument-order
  - storing the class info during execution

Conclusions

- Precision
  - high precision because it actually compares the behavior of class with expected behavior
  - improve precision by allowing input constructor, observer and modifier
- Recall
  - improve recall by allowing defined constructor to create instance & by neglect argument order
- Efficiency
  - type checking & run time storage

Future work

- It can be extended to include the user-defined types
- Access modifier matching can be added to before execution