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Learning the Course of Design and Analyze of Computer Algorithms via Online Coding

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ABSTRACT

The course of design and analysis of computer algorithms is one of the core-course of computer science education; this paper presents an online coding framework to help students to learn the course of design and ananlysis of computer algorithms and other coding-related courses in computer science. With the online coding framework, a student can edit code in any web browser, and then executes it. This online coding framework can connect teachers, curriculum authors, and students in a unique social experience by tracking and streaming progress updates in real time. In particular, with the newly proposed framework, it is not difficult to find interesting and unexpected input values during students'practicing, and then help them to understand what their code is actually doing.

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1. INTRODUCTION

In order to achieve the goals of teaching to complete the common task of teaching, teaching methods adopted by teachers are the critical means to educate students in the class[1,2]. Especially, since computer science is a typical engineering-related field, there must be certain special engineering-related motivations for computer science education, such as arousing students' interests in coding, cultivating students' analysis ability for find the errors in the software, and stimulating students' sense of innovation to create some novel software.

On the other hand, in computer science education, the course of design and analysis of computer algorithms is part of the core curriculum and compulsory for all students who major in computer science. However, the current situation is that the non-computer professional students lack of program design, data structure and other background knowledge to follow the course. Therefore, the students generally feel abstract, difficult to understand, cannot be linking theory and practice, so that the theoretical knowledge for students study interest is not high and the teaching effectiveness is not attractive [2]. Moreover, other coding-related courses in the computer science education have the same dilemma in colleges and universities.

This paper tries to provide an online and game-like interface to learn the computer science courses, such as the course of design and analysis of computer algorithms. Therefore, with this newly proposed and implemented framwork, the students can write, compile, and run their codes to learn programming concepts, practice-coding skills, and analyze the behavior of code interactively.

2. TEACHING SITUATIONS AND RELATED WORK

In this section, we will introduce the current teaching situation about the course of design and analysis of computer algorithms; then certain related work about the approaches for improving the teaching

skills on the course of design and analysis of computer algorithms or other coding-related courses will be discussed.

2.1 Course Description

The course of design and analysis of computer algorithms introduces some basic data structures such as list, tree, graph and several correlative algorithms, including divide and conquer, greedy, dynamic programing, backtrace and their implementations. The objectives of this course includes:

- to learn good principles of algorithm design;
- to learn how to analyse algorithms;
- to become familiar with fundamental data structures and their best implementations;
- to become accustomed to the description of algorithms in both functional and procedural styles;
- to learn how to apply their theoretical knowledge to solve the problems in the real world.

In total, the main purpose of the course is to improve the ability for solving real world problems using a computer programing or other related techniques. As a matter of fact, many of the concepts in the course of design and analysis of computer algorithms are extremely abstract and difficult to learn. For example, stack is a very basic and abstract concept but is used almost everywhere in programing, such as implementing an operating system. On the other hand, many students always encounter some difficulties whileconvertingan abstract concept to an executable program, i.e. implementing a program that uses the abstract. Therefore, a teacher should direct students through this process. As college teachers, we have used many teaching approaches in this course in order to make the abstract and illusive concepts more acceptable to our students. Below, we give a brief introduction to the current approaches adopted by the most of teacherscurrently.

2.2 Simplex teaching skills

In general, teaching methods use multimedia courseware for introducing the ideas in the textbooks, in the explanation process also supplemented by traditional methods such as whiteboard. The following approachs are always used for teaching the course of design and analysis of computer algorithms:

- Problem-oriented teaching (POT)

  Sometimes, in the middle of a class, some real world problems will be mentioned for demonstrating how to use the knowledge they have learnt to solve the problems.
- Doing exercises in practical class

  There are some practical classes for the course where the students can do some exercises to confirm the theory learnt before. It is the teacher's responsibility to help them coding to solve the assigned problems in the laborartory.
- Doing homework

  The homework is assigned to students once or twice per week, and ensures that they can submit their work on time. Part of the homework should be checked so that the teachers can know how well the students have mastered the knowledge that have been taught, and what kind of problems they have. According to their progress, certain supplementary material will be provided to some students for fastening the concepts.
- Using multimedia and hypermedia in lectures

  Extra multimedia and hypermedia are able to make the lessons active and impressive, so that the abstract concepts can be easier to remember as well.
- Using FTP

  Students can submit their homework to the specific FTP site, where the teacherscan put tutorials and marks as well. In this way, communication with the students is effective and convenient.
- Using email or instance messager to communicate with students

  With the exception of formal lectures, teachers and students have little time for teaching and learning face to face. Therefore when students experience difficulties, there is little opportunity to ask teachers for help. So that, sending emails and chating via an instant messager are good ways for teachers and students to communicate with each other.

2.3 Related Work

There are many researchers have proposed certain approaches for improving the teaching effectivenss about the course of design and analysis of computer algorithms. L. Chen et al. discussed the problems about strengthening student's programming skills and cultivating their innovational idea with the course of Algorithms Design and Analysis, and further advanced the tentative idea of the teaching reform [4]. H. Sun et al. discussed how to teach in accordance with students' characteristics and carry out classed which

take the students as the center, then it may find ways to improve the teaching effect and quality in the class of algorithm design and analysis. And there is strong practical significance in the aspect of raising students' specialized interests [6]. The reform introduced in [5] rebuilds task-driven and situational teaching. Approach to algorithm design strategy based on task while in the application and design of data structures, re-integration of knowledge, so as to implement teaching. Practice shows that the combining is more conducive to stimulate students interested in learning and increased learning efficiency and to develop students' ability to design independently algorithm and analysis capacity.

Moreover, J. Zhao [7] does not only analyses the theory of web-based cooperative learning [8], learning content and learning pattern, but also proposes relevant implement measures combining the course features of algorithm analysis and design. They have conducted some experimental evaluation, and the experimental results show this web-based cooperative learning is fairy attractive.

3. THE FRAMEWORK OF ONLINE GAMING AND CODING

This paper proposes a framework of online codingwhich is named as Gmei, to allow students writing and running codes in web browers. Moreover, the teachers can also deploy their tasks to require the students to finish them. In a game-like way, a student can write, compile, and run code in order to learn programming concepts, practice coding skills, and analyze the behavior of code interactively. Gmei's web site is given using an interactive style with slide handouts, slide presentation, demos, and discussions. All participants can carry out interactive exercises on the web site under the guidance of the teachers. Moreover, certain skills and knowledge of using this newly implemented system in teaching and learning are expected to be gained by the participants, including both teachers and students.

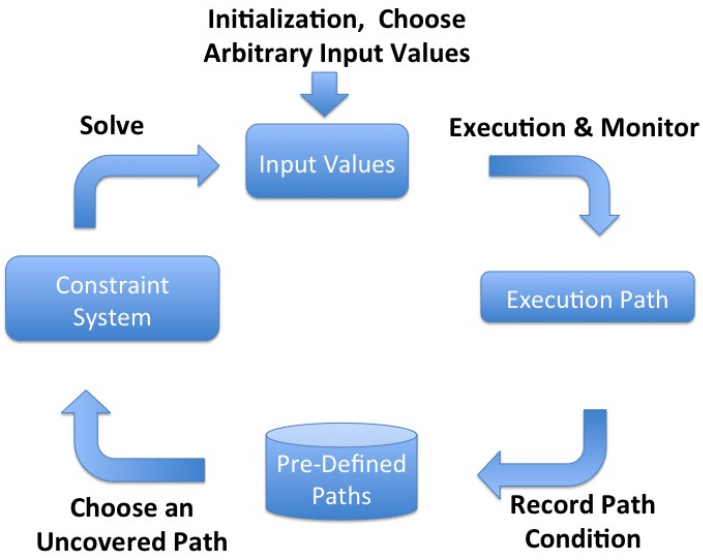

Figure 1. The Architecture of Online Coding in Gmei

Figure 1 shows the architecture of Gmei, it generates input values by analyzing the program code provided by the stduents. For every statement in the code, Gmei eventually tries to create input values that will reach that statement. It performs a case analysis for every conditional branch in the code. For example, if statements, assertions, and all operations that can throw exceptions. To put it from another angle, the number of input values that generated by Gmei depends on the number and possible combinations of conditional branches in the code. Besides, Gmei operates in a feedback loop; it executes the code multiple times and learns about the program's behavior by monitoring the control and data flow.

After each loop of execution, Gmei does the following operations:

1) Chooses a branch that was not covered previously.
2) Builds a constraint system that describes how to reach that branch.
3) Uses a constraint solver to determine new input values that fulfill the constraints, if any exist.

The code is executed again with the new input values, and the process repeats. On each loop of execution, Gmei might discover new code and dig deeper into the implementation. In this way of execution and learning, Gmei can explore the behavior of the code exactly.

3.2 Case Study

In this section, we will conduct a case study, which creates a courseof design and analysis of computer algoriths to show that Gmei can be used generally to build interesting, engaging, demanding classes on mathematics, algorithms, programming languages, or problem solving. In particular, a teacher combines existing materials, such as slides and demos, into the course. The materials might have been written by the teacher or by any other author. Then, the teacher can invite students to the course by sharing a registration link with them. A course can have multiple teachers. Any user can become a student by registering for a course through the registration web page. The student can then work through the pages that are part of the course. To pass the course, the student completes exercises in the form of coding practice. After the study, the student can unregister from the course at any time.

We will describe how to create and publish a new problem, so that other people can discover and conquer it by coding.

1) Step One: Sign in, so that Gmei can maintain coding instance for the us. if we create a coding instance without signing in first, we will have to maintain links and other information ourself about the coding instance. Besides, we can have nicknames and allow our nicknames to be shown with our published coding instance.
2) Step Two: write a specification about the implementation details of the designated algorithm. Currently, the teacher can write the specification as a C++language that takes inputs and produces an output, fulfilling the coding instance. Figure 2 shows an example of specification ofbubble sort.
3) Step Three: create the coding instance
   The problem can be convert into a coding instance. After that, the students can see this coding problem but without the codes shown in Figure 2. Then, the students can edit their codes and put them into compiler that behind the Gmei web site. The execution results will be presented in the brower if the program is correct. Otherwise, the error information will be shown to alert the relevent students.
4) Step Four: coding and conquering the coding problem:the students can edit and run their codes in web browers. At last, if students' programs can conquer the problem, the codes will be kept by the system and reported to the teachers, i.e. the manufecturer of the coding problem.

«BubbleSort» - Click to open

```
using System;
public class Program {
  public static int[] Puzzle(int[] a) {
    a = (int[])a.Clone();
    for (var i = 0; i < a.Length - 1; i++) {
      for (var j = 1; j < a.Length - i; j++) {
        if (a[j] < a[j - 1]) {
          var tmp = a[j];
          a[j] = a[j - 1];
          a[j - 1] = tmp;
        }
      }
    }
    return a;
  }
}
```

4. SUMMARY

In this paper, we analyze the problems during the teaching of the course of design and analysis of computer algorithms, and proposed an online coding framework named as Gmei, so that a student can edit his/her code in any browser, executes it, and then analyzes it. This newly proposed framework connects teachers, curriculum authors, and students in a unique social experience, tracking and streaming progress updates in real time. Especially, for the course of design and analysis of computer algorithms, through using this framework, the teachers can find interesting and unexpected input values that help students to understand

what their codes are actually doing. The real fun starts with coding instacnces where students write code to implement the teacher's specifications about the typical algorithms in computer science, such as greedy algorithm, backtrace and dynamica programing.

A questionnaire survey on students at the end of the course demonstrate that more than 96% of them believe tthat the program helped them more, such as increasing interests in learning computer science, promotingcoding skills, and laiding a good foundation of team concept when they enter the industry company after graduation.

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