

# A Study of the Visualization Tool for Computer Science Majors' Capability Assessment

Feng Ye, Yong Chen, and Qian Huang

**Abstract**—IT industry burgeoning, more and more enterprises and universities pay attention to the comprehensive ability of computer science majors. However, the existing assessment method giving priority to test scores, could not greatly demonstrate computer science majors' capability and their development approaches, with drawbacks of serious one-sidedness, limitation and low perceptual intuition. Correspondingly, it's difficult to teach students according to their aptitude or interests. Moreover, the current research works show that this research field still requires theoretical foundations, appropriate models, effective tools, in-depth experimentations and practical implementations. In order to solve this problem, the paper proposes an index system of students' for evaluating computer science majors' ability, designs and implements the relevant visualization software of capability assessment based on dynamic radar charts and jitterplot, and then illustrates the application of this visual software through case studies. Based on the visualization tool, it has achieved good results in practical teaching.

**Index Terms**—Visualization tool, radar chart, jitterplot, capability assessment.

## I. INTRODUCTION

IT industry burgeoning, more and more enterprises and universities are deeply aware that the capability of computer science majors is closely related to the future of the whole industry. Under such a background, enterprises and universities both at home and abroad pay more attention to the comprehensive ability of computer science majors, including knowledge acquisition, innovation, team collaboration, language expression and communication, programming, scientific research, etc. However, the existing assessment method giving priority to test scores, lacks the comprehensive mechanism to fully demonstrate computer science majors' capability and their development approaches, with drawbacks of serious one-sidedness, limitation and low perceptual intuition. Correspondingly, it's difficult to teach students according to their aptitude or interests. Therefore, it is very significant and valuable to study how to evaluate computer

science majors' capability and development reasonably, and presents it in a visualized way. For example, when students apply for jobs, they are easier to make employers understand their specialty and ability by using visualized evaluation results aimed to show their achievements, characteristics, development approaches and so on. Either, with this kind of evaluation tools, teachers and counselors grasp students' development state and level of capacity in a visualized way directly, so as to provide corresponding learning contents and guidance, and further fulfill individualized education in a real sense.

With the rapid development and strong support of big data [1] and visualization technique [2], teaching evaluation, capability assessment and learning analysis progressively shift from the traditional empiricism to objectivity and from fuzzification to visual clarity. Big data and visualization technique can innovate a new mechanism for teachers to track, focus on, evaluate educators' leaning processes and outcomes. What's more, they will not only effectively improve the ability of computer science majors' capability assessment and display, but will provide us with the most direct, objective, accurate training foundation. However, the current research works show that this research field still requires theoretical foundations, appropriate models, effective tools, in-depth experimentations and practical implementations. Thus, this paper proposes a comprehensive index system for evaluating these students' ability, then designs and implements the visualized software tool of capability assessment based on dynamic radar chart and jitterplot.

The rest of the paper is organized as follows. The Section II describes some of the works related to our topics of interest. The comprehensive index system for evaluating computer science majors's capability is proposed in Section III. In section IV, the development and the key technology of visualization software tool is introduced. The Section V presents the use cases and discussion. At last, conclusion along with the direction for future research has been provided.

## II. RELATED WORKS

The demand and ability of the country and society for computer science major are closely related to the goal and process of national informatization and intelligent manufacturing strategy. According to fundamental interests of the state, computer science major in institutions of higher education is required to train innovative research talents mastering basic theories and core technologies. IT enterprises usually expect students majoring in computer science become engineering talents to promote the continuous upgrading and development of software products with good capability of

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practice, sense of cooperation and learning ability. For some other application-oriented industries, they are also required to possess communication skills, ability of application practice, etc., to apply computer technology to practice. How to evaluate students' abilities of computer science majors comprehensively and reasonably become the key problem.

Currently, for the situation above, many researchers have focused on and proposed some research methods. L. J. Zheng [3] analyzed the demand structure of software talent and built the evaluation index system, and then gave a specific evaluation example. In [4], the authors proposed a multilevel fuzzy comprehensive evaluation and analytic hierarchy process to compute the evaluation weight set, which accomplishes to give comprehensive judgement to computer science department student about their practical ability. In [5], Z. H. Su applied the fuzzy logical feature mapping artificial neural network to the evaluation of the graduates' theoretical basis and application ability, and then he verified the effectiveness of the algorithm. S. B. Ren [6] proposed a teaching reform approach based on CDIO capability maturity model, and constructed the four-stage teaching pattern centered on fostering engineering capability. The works above studied the capability assessment of students' from different standpoints, but all of them did not implement the visual software tools for educators.

In [7], the author constructed an evaluation system of ability of students major in computer application in higher vocational schools, and development the software for the evaluation system. An information system of students' assessment of the capacity for a vocational school was developed and introduced in [8]. However, the evaluation indexes are presented in a very simple way for both of them. Therefore, we need to design a comprehensive index system, and then implement a visual software tool according to the index system.

To sum up, the methods of designing different evaluation indexes for computer majors are diverse, but this research field still requires theoretical foundations, appropriate models, effective tools, in-depth experimentations and practical implementations. Specifically, visual presentation can lead to a more intuitive and efficient assessment for computer majors because of the comprehensive index system.

### III. AN INDEX SYSTEM FOR EVALUATING COMPUTER SCIENCE MAJOR'S CAPABILITY

Based on Delphi method [9], the proposed index system of computer science majors' capacity assessment can be represented by a quintuples P:  $P = \{Bas, Pro, Pra, Cre, Act\}$ . *Bas* refers to computer science majors' basic ability in mathematics and foreign languages, which can be reflected by their grades in advanced mathematics, discrete mathematics, probability theory, linear algebra and foreign languages. *Bas* could be calculated by formula (1):

$$Bas = \frac{\sum (grade\ point * credit)_{basic\ curriculum}}{\sum credit} \quad (1)$$

*Pro* refers to the professional ability measuring students' mastery of main courses in computer science, which can be

reflected by grades in some courses, such as algorithms and data structures, database, programming methodology, software engineering, operating system and so on. *Pro* could be calculated by formula (2):

$$Pro = \frac{\sum (grade\ point * credit)_{professional\ curriculum}}{\sum (credit)_{professional\ curriculum}} \quad (2)$$

*Pra* refers to the practical ability showing students' ability of practice, programming, software installation and code debugging, which can be reflected by either grades of computer operation or their participation in professional competitions, such as China Software Cup, ACM International Collegiate Programming Contest [10]-[12], etc. *Pra* could be calculated by formula (3):

$$Pra = \frac{\sum (grade\ point * credit)_{experimental\ course} * \alpha}{\sum (credit)_{experimental\ course}} + \sum contest\ award * (1 - \alpha) \quad (3)$$

In formula (3), the contest award of national level could be counted as 5 points, of provincial level as 3 points, and of participation as 1 point. It is consistent with five-grade making system in the course. And the coefficient  $\alpha$  can be dynamically set according to the needs of assessment. For example, when there are fewer contest award, we can set the coefficient  $\alpha=1$ .

*Cre* refers to innovation ability reflecting computer science majors' declaration of invention patents and scientific paper writing. Therefore, the calculation of innovation ability can be made in formula (4):

$$Cre = \sum (5 * num1 + 3 * num2 + 1 * num3) \quad (4)$$

In formula (4), num1 represents the number of paper in SCI or EI journal article, num2 represents the number of paper in EI meeting, Chinese core periodicals and declaring invention patent, and num3 represents the number of the common scientific articles and declaring other kind of patents. Publishing one paper in SCI, EI counts 5 points; publishing one work in EI meeting, Chinese core periodicals and declaring invention patent count 3 points; publishing the scientific article and declaring other kind of patents count 1 point. For example, if an excellent student finished two papers by his third year, and the papers were retrieved by SCI journal and EI meeting respectively, then his *Cre* is 8.

In terms of the rapid progress in computer technology, it is also very important to examine and evaluate students' active learning ability *ACT*, which embodies their changes in learning process. In order to define it, we choose to use the Hale Index Valuation [13], [14] to calculate "Progressing Mark", that is, to use exponential equation to clarify the achievement and difficulty. Then, *ACT* is assessed on the basis of the progress of higher and lower achievers, different weight of the difficulty and "Progressing Mark" accumulated in two academic years. Because distinct courses in each semester have great differences, in the actual calculation, scores could be regarded as grade point averages of professional courses and experimental classes which are used to calculate *Pro* and *Pra*, and later T-score and Progressing

Mark could be counted with Hale index method.

Take data of two students (No.1 and No.2) selected randomly as an example (data from the educational administration system of Hohai University). From Table I, we can see No.1 has good grades in basic courses and higher scores in professional courses, showing great professional abilities; gains full marks or even the first prize in the contest, reflecting excellent performance in experimental classes and competitions; possesses 3 invention patents, revealing outstanding innovation ability and progressive active learning ability as the academic year increasing. No.2 is excellent in basis courses, but less outstanding in professional courses. She has good practical ability, but need improve further in innovation for she makes no contributions in this respect. Further, her active learning ability is stable. (see Table I).

TABLE I: THE SAMPLE OF GRADES IN COURSES AND CONTESTS OF FRESH GRADUATES OF 2008-2010 SESSIONS

No.	Basic ability	Professional ability	Practical ability	Innovation ability	Active leaning ability
1	4.02	4.35	5.0	3	14.7
2	4.41	4.10	4.0	0	13.0

#### IV. DEVELOPMENT OF VISUALIZATION SOFTWARE TOOL

When it comes to computer science majors' capability assessment, it is difficult and not clear to show multi-attribute data with the sheet alone. For the visualized mechanism that reflects characteristics of multi-attribute data or relationships among data, radar chart [15]-[17] is one of representatives. It is organized by a number of equidistant concentric circles representing certain scores which are gradually increasing from the center to outward circles. It also consists of a sequence of spokes outward, each of which represents an evaluation index. Then, each index value is normalized processed and scaled on its axis. Next, radar chart representing and evaluating each index is obtained, after points on adjacent axes of two-dimensional plane are sequentially connected. Combining graphs and data, comprehensive evaluation method based on radar chart extracts characteristic values in the chart by nonlinear transformation of data, uses comprehensive evaluation function to calculate the evaluation function value and then reflects the comprehensive evaluation result of the object.

For comparing individual performance with peers, we choose jitterplot [18] as a visualization mechanism, which can make it easy to see how well or poorly a student performed compared to other students. In a jitterplot, it is the color more than anything else that makes the individual's ratings pop out from all the other ratings. The selected individual's dot is centered horizontally, but it is the different color that does the most to make the selected person stand out.

In order to generate the Web-based dynamic radar chart and jitterdot visualization mechanism according to students' grades achieved in each semester, Bootstrap [19], D3.js [20], [21] and Ajax [22] techniques have been mainly used. Bootstrap is a free, open-source collection of tools for creating responsive web sites and web applications. The templates of Bootstrap are based on HTML5 and CSS3, and

cover navigation, typography, forms, buttons, and other web site components, as well as optional JavaScript extensions. Following the Web standard, D3.js is a visualized drawing library based on JavaScript and HTML. It manipulates documents with data and then brings data to life vividly by using HTML, SVG, and CSS, independent to any particular browser. Its display function for realizing dynamic radar charts has been embedded into the framework implemented by Bootstrap. Ajax can be used to refresh a web page dynamically, that is, to request certain operations from the server, and then to change some of web pages or prompt users' related information, etc., rather than reloading the entire page. Its essence is an asynchronous JavaScript request operation, significantly improving users' experience. Therefore, in the system, Ajax is used to obtain the evaluation value of student's capability stored by back-end in the database, then to update and display it in the front-end.

Take the radar chart for example. The key code for the radar chart is as follows.

```
public class RadarAction extends ActionSupport {
    private String strAnalyzeResults;
    public String getStrAnalyzeResults() {
        return strAnalyzeResults;
    }
    private String convertResultsToStr(Map<Integer,
        AnalyzeResult> results){
        private float basicAbility , theoryAbility, operationalAbility,
        progress, learnAbility , StringBuilder ;
        sBuilder=new StringBuilder("");
        for(int i=1;i<=4;++i){
            AnalyzeResult result=results.get(i);
            sBuilder.append(String.format("%f,%f,%f,%f,%f;",
                result.getBasicAbility(), result.getTheoryAbility(),
                result.getOperationalAbility(),
                result.getProgress(),result.getLearnAbility()));
        }
        sBuilder.deleteCharAt(sBuilder.length()-1) ;
        return sBuilder.toString();
    }
}
```

#### V. CASES AND DISCUSSIONS

Currently, scores of fresh graduates in the college have been calculated according to the evaluation index system, and the results are stored in the database. Radar chart could display one of students' capability when their names and numbers in the drop-down box are chosen and clicked. Fig. 1 shows the dynamic radar chart of one student's (No. 1) different capabilities in the first and third year, in which distinct colors are used to distinguish shapes in different academic years. It is not difficult to see that No. 1 has always maintained active learning ability, made significant progress especially in innovation ability and practical ability. However,

due to the limited progress in basic and professional competence, teachers have to supervise his related courses in this respect.

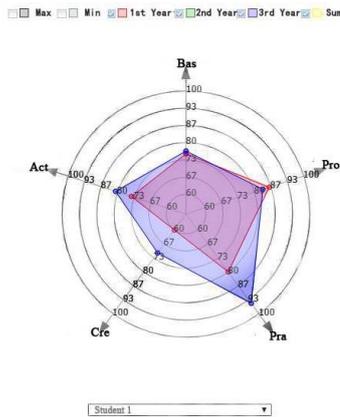


Fig. 1. Display and comparison of radar chart of one student’s capability in the first and third year.

Fig. 2 shows the dynamic radar of student 2 and it reveals a dynamic radar chart of another student during undergraduate studies. In this figure, the area coverage of the radar is getting larger gradually. Apparently, the area in senior grades covers that in junior grades. Thus, it is easy to show that student 2 has made progress in all aspects during the university.

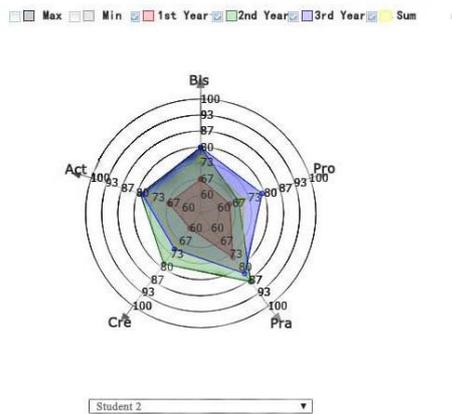


Fig. 2. Display and comparison of radar chart of another student’s capability during undergraduate studie.

Fig.3. shows a student’s ranking comparison with peers using jitterdot. From this jitterdot, we’ll look at comparing an individual score versus the aggregate of all scores in a moment, but seeing all the dots allows presenters to see not just where they are relative to others but also just how many other people were rated.

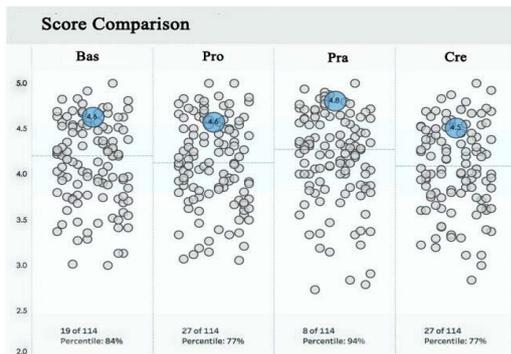


Fig. 3. The jitterdot of a student’s ranking comparison with peers.

With three instantiate functions above, the evaluation index system with the display of radar chart and jitterdot allows teachers to understand each student’s capability timely in each academic year, and to pay close attention to their strengths or progress. For instance, one student has a good ability to innovate, or still need great assistance in practical ability. In addition, this visual software tool provides the most direct, objective and accurate training foundation for teachers and students through comparisons of different academic years and of different students. Obviously,

## VI. CONCLUSION

A scientific evaluation system can fully understand the learning process of students, promote the overall development of students and improve teaching. Such an index system for assessing capabilities of computer science majors having been put forth, visualized software of capability assessment has been developed in collaboration with the professional firm, based on the dynamic radar chart. The visual software effectively evaluates and displays capabilities of computer science students and offers more direct, objective, accurate data results. On the basis of current research, it is proposed to further improve big data processing mechanism, function of analysis and comparison, etc., to optimize users’ experience, to provide more help for teaching and students recommendation.

In future, as the number of students and data increases, we will adopt Apache Spark [23] as the big data processing framework to upgrade existing visual software tool. Its strong data processing capability and abundant machine learning algorithms will be easy to deal with more query requests and data analysis requirements.

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