Automatic Grading of Online Graph Plotting Problems

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Abstract

In mathematics education, students are frequently tasked with drawing graphs that accurately represent given mathematical formulas. This paper presents a novel method for the automated grading of student-drawn graphs within a learning management system (LMS). Our work specifically utilized Bézier curves and Oshima spline curves (a variant derived from Bézier curves), developing assessment questions with the aid of the dynamic geometric graph software "KeTCindy".

1 Introduction

Automatically grading problems that require drawing function graphs in online math classes is challenging. The difficulty stems from the fact that humans can easily interpret even slightly imperfect graphs, whereas algorithms require clear rules. While linear and quadratic functions might be relatively straightforward, higher-order or more complex functions pose a greater challenge for automatic evaluation. So, we developed Moodle quiz questions using Oshima spline curves and the "KeTCindy" software to automatically grade graphs drawn by students.

2 Example of teaching material

As an example, let's consider the problem of drawing a graph of the following function:

$$y = \frac{1}{2}(x^3 - 3x)$$

First, students find the points of intersection with the y-axis and the local maximum and minimum points by differentiation. Next, students can freely move points on the KeTCindy([1]) graph canvas and the curve is automatically drawn along the curve generated by the Oshima spline([2]).

We calculate the average error of the y-coordinates between the graph of the function drawn with the Oshima spline curve and the graph of the function $y = \frac{1}{2}(x^3 - 3x)$, at points where the x-coordinate is $-2, -1, 0, 1, 2$ (refer to line 7 in Figure 1).

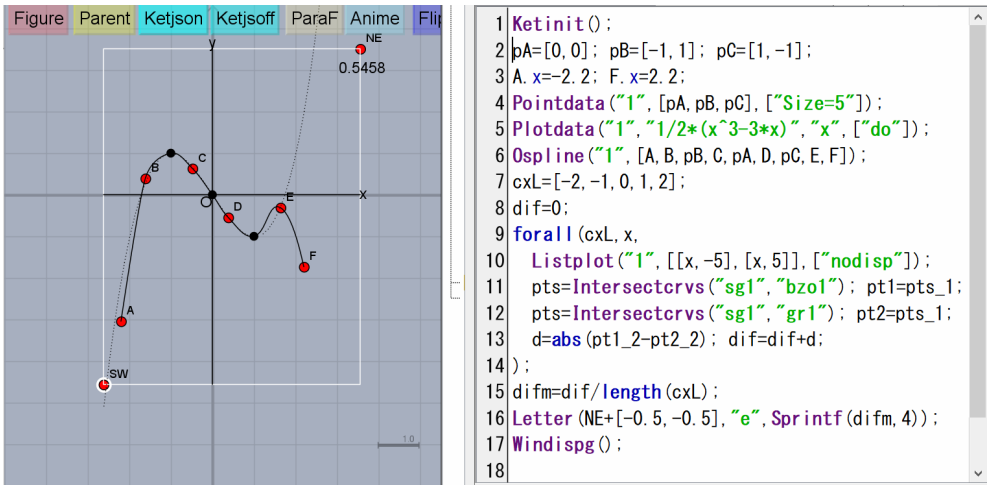

Fig.1 The left : KeTCindy drawing screen, the right : script screen

In the right graph of Figure 2, the error is 0.4142, and in the left graph, it is 0.0730. Therefore, if the error is 0.1 or less, it is considered to be correct, and the graph can be graded.

Finally, the published HTML file is integrated into Moodle's quiz feature using the "iframe" command. Through these steps, we create a Moodle quiz that allows for correct/incorrect judgments based on geometric properties.

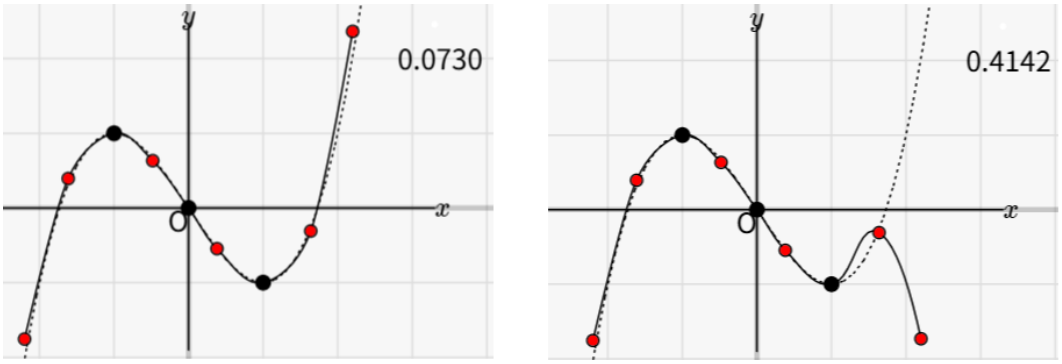

Fig.2 HTML file of the function graph generated by the Oshima spline

3 Future Work

STACK (System for Teaching Assessment using a Computer Algebra Kernel) is a system that can automatically grade mathematical expressions and can be used as the "quiz" functions in Moodle. We would like to consider incorporating automatic grading questions for graphs created with KeTCindy into STACK as well.

References

[1] KeTCindy Home `https://s-takato.github.io/ketcindyorg/indexe.html`

[2] Setsuo Takato, José A. Vallejo, Using Oshima Splines to Produce Accurate Numerical Results and High Quality Graphical Output, Math.Comput.Sci. (2020) 14:399–413, 2020.