Cooperation of KeTCindyJS and Maxima

Masaki Suzuki

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Department of Liberal Arts, National Institute of Technology, Numazu College

Introduction

- Digitalization of education (in Japan)
  - The GIGA School Initiative (Global and Innovation Gateway for All)
    - ICT devices are provided to each student.
    - The local area network infrastructure has been developed in the school.
  - A digital transformation plan by Ministry of Education
    - The digitalization of textbooks is progressing.
    - Lessons are being conducted using videos and slides.
    - E-learning platforms are actively in use.
- Online classes due to the COVID-19 pandemic
  - Online classes have accelerated the digitalization of education.

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⇒ Need to improve both quality and quantity of online materials.

⇒ I have been working on creating various HTML-based teaching materials using KeTCindyJS.

KeTCindy / KeTCindyJS

- KeTCindy
  - A tool for inserting figures created with the dynamic geometry software Cinderella2 into LaTeX documents.
- KeTCindyJS
  - A figure creation and HTML conversion system based on CindyJS (Cinderella2 framework), utilizing the KeTCindy library.
- KeTCindy and KeTCindyJS were developed by a group led by Professor Takato.

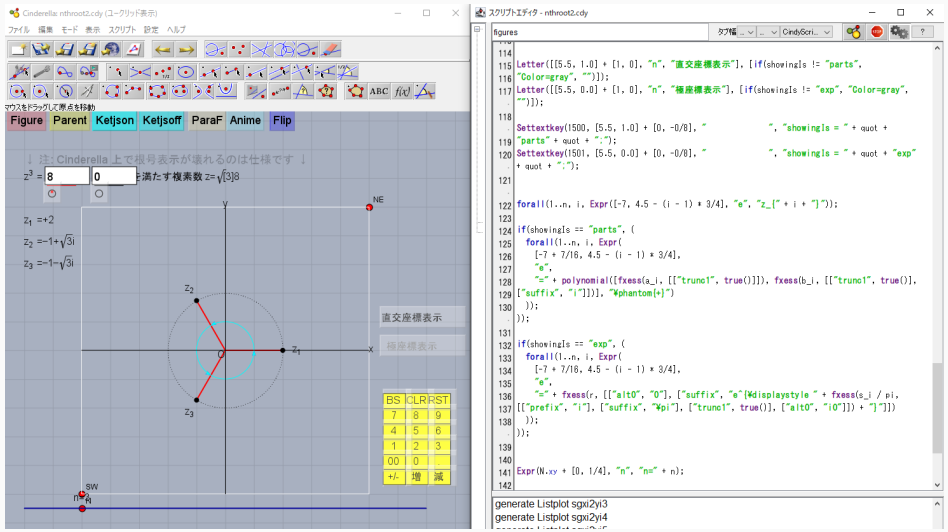

Figure 1: The drawing screen of KeTCindy / KeTCindyJS

Example of HTML teaching material with KeTCindyJS

- The following materials I developed are published on the WEB Contents site of Dainippon Tosho Co., Ltd. .

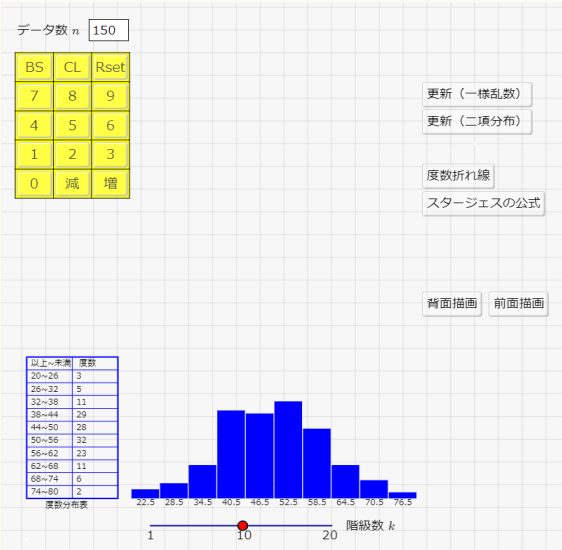

Figure 2: Histogram

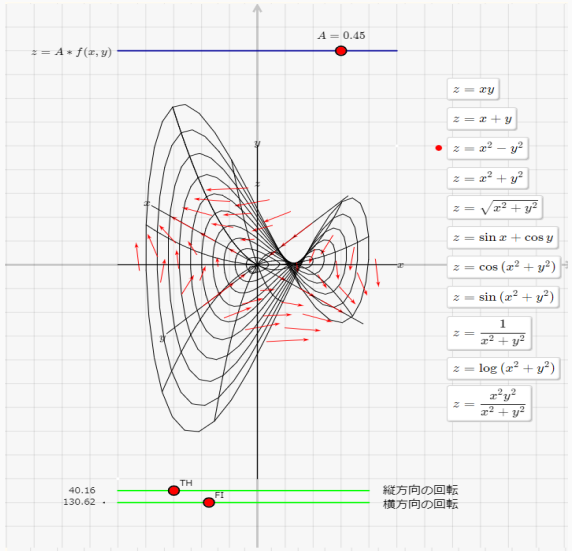

Figure 3: Gradient

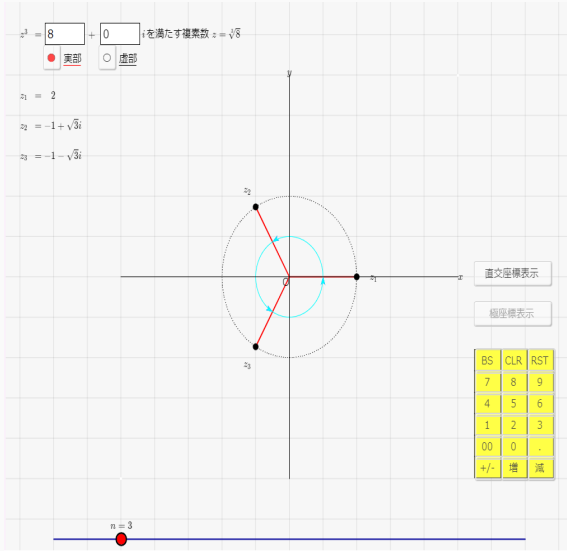

Figure 4: Nth-root

- Other materials, including some created by students, are partially available on my personal website.

Purpose

- By using KeTCindyJS, one can create HTML-based teaching materials with some ideas and a bit of programming skill.
- KeTCindyJS is suitable for mathematical visualization, but errors occur in the results because the operations are numerical calculations.
    - For example, Figure 2 - 4 merely gives the appearance of a correct computation.

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Purpose

The purpose of this study is to create online teaching materials that provide new insights into online educational content by combining KeTCindyJS, which excels at mathematical visualization, with Maxima, which is capable of symbolic computation.

Numerical Computation and Symbolic Computation

- Compare errors using Taylor expansion as an example
  - Numerical differentiation (KeTCindy script) is accurate up to the fifth-order term, but substantial errors arise beyond that.

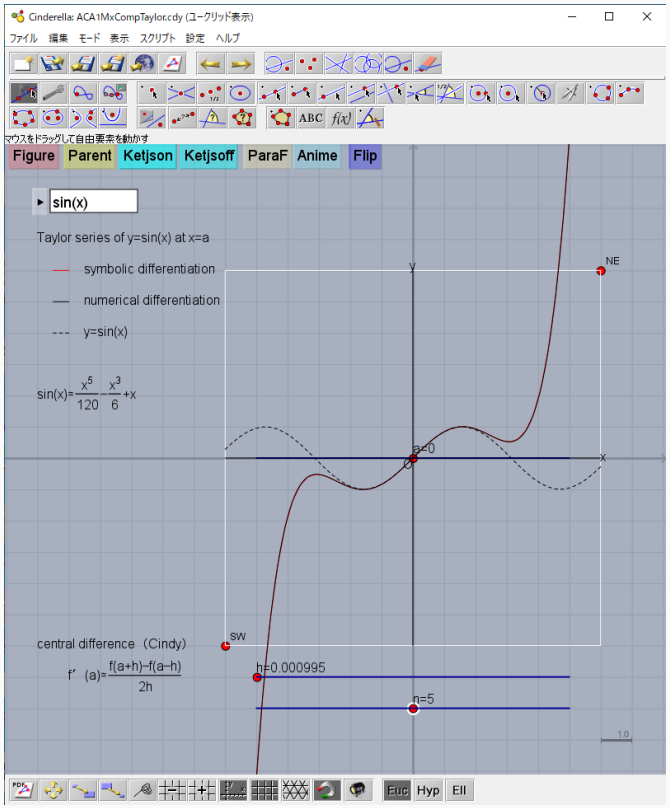


Figure 5: 5th-order approximation

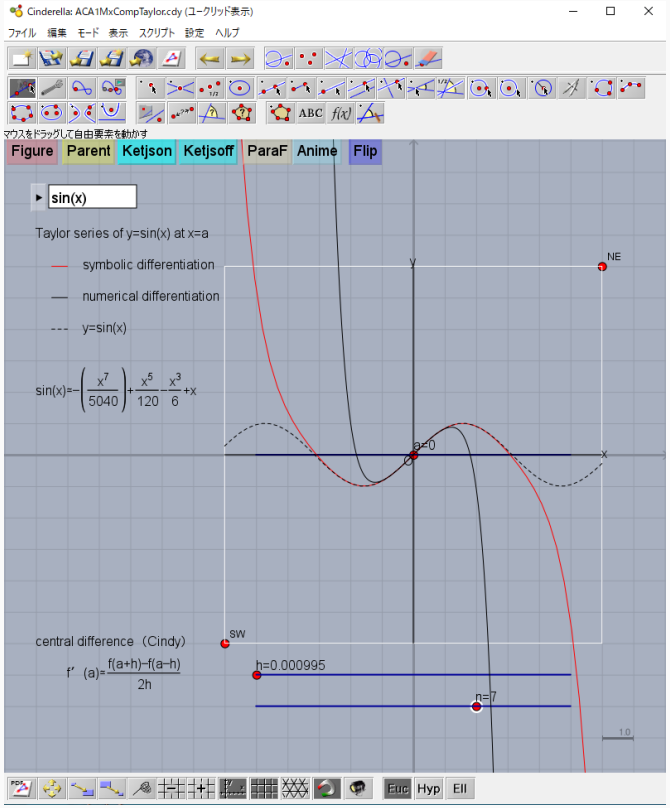


Figure 6: 7th-order approximation

KeTCindyJS Script for Maxima

- CalcbyM():Run the Maxima script
- Mxfun():Run the Maxima function
- Mxtex():Convert the result of Mxfun() into TeX format
- ketcindyjsdata() : Enable the use of Maxima output in KeTCindyJS

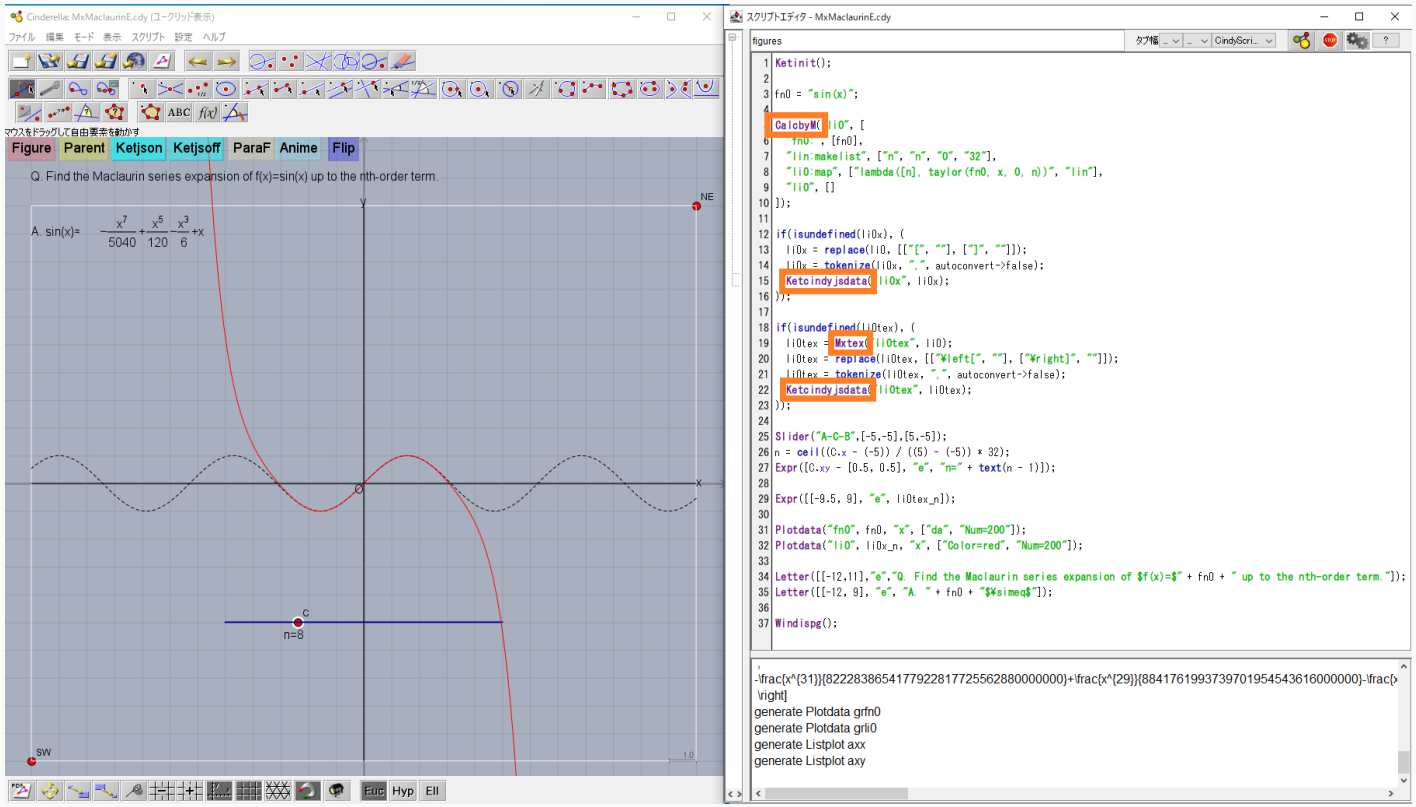


Figure 7: KeTCindyJS Script for Maxima

From Cindy file to HTML filee

1. Click "Export as HTML file" from the File menu. (Ctrl + E)
2. Press the "ketjson" or "ketjsoff" button.

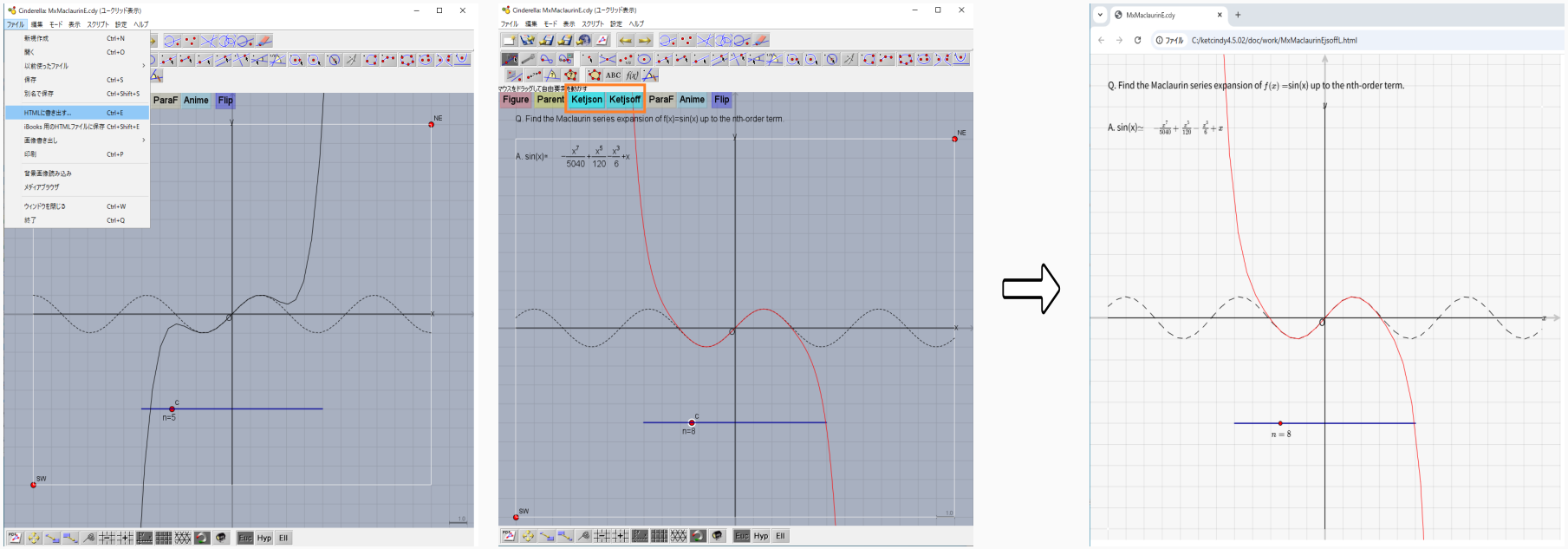


Figure 8: From Cindy file to HTML file

Example of teaching material 1

(I explain examples of teaching materials using a video.)

- Taylor expansion
  1. Compute the nth-order derivative by using Maxima.
  2. Draw the graph of the nth-order approximation using KeTCindy.

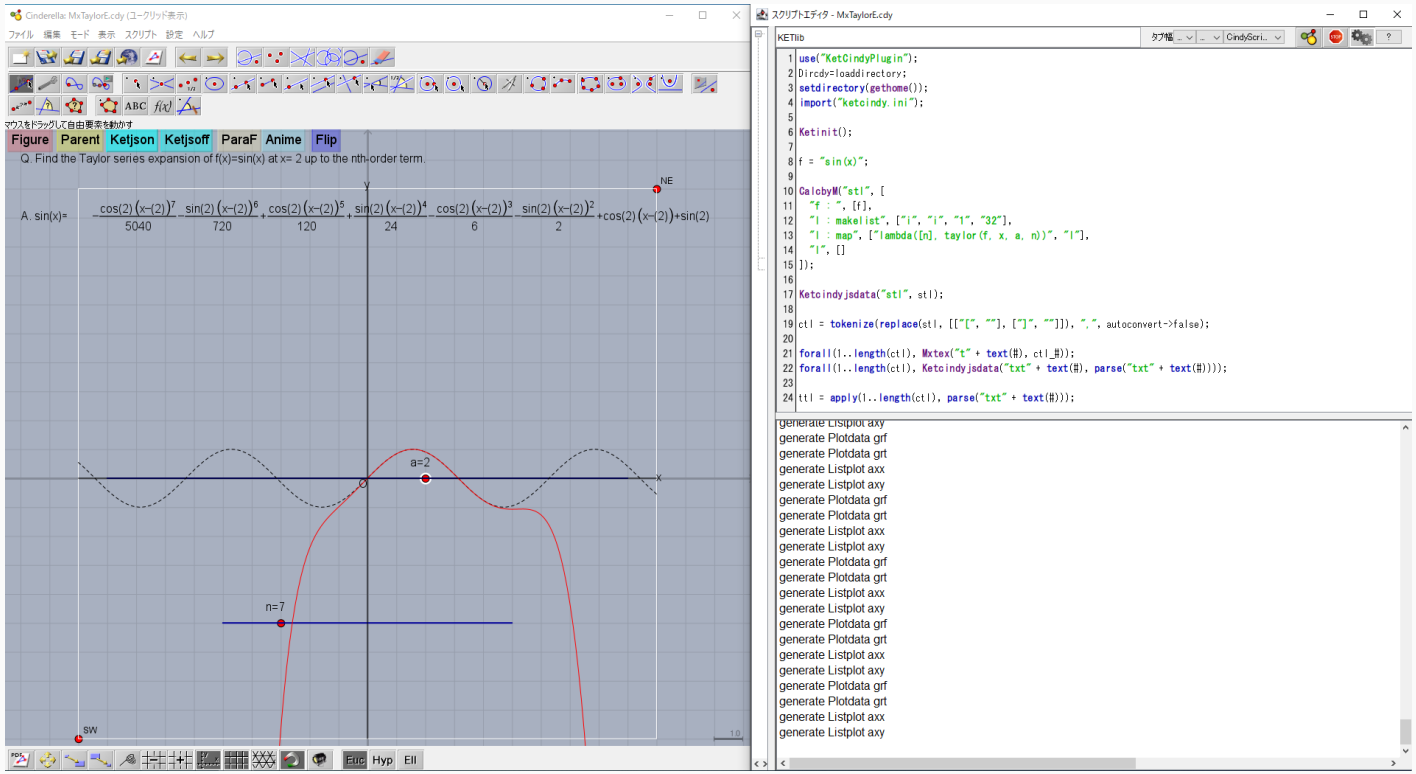


Figure 9: Cindy Script for Taylor expansion

Example of teaching material 2

- solution of an nth-degree equation
  1. Solve an nth-degree equation using Maxima.
  2. Mark the solutions on the graph using KeTCindy.

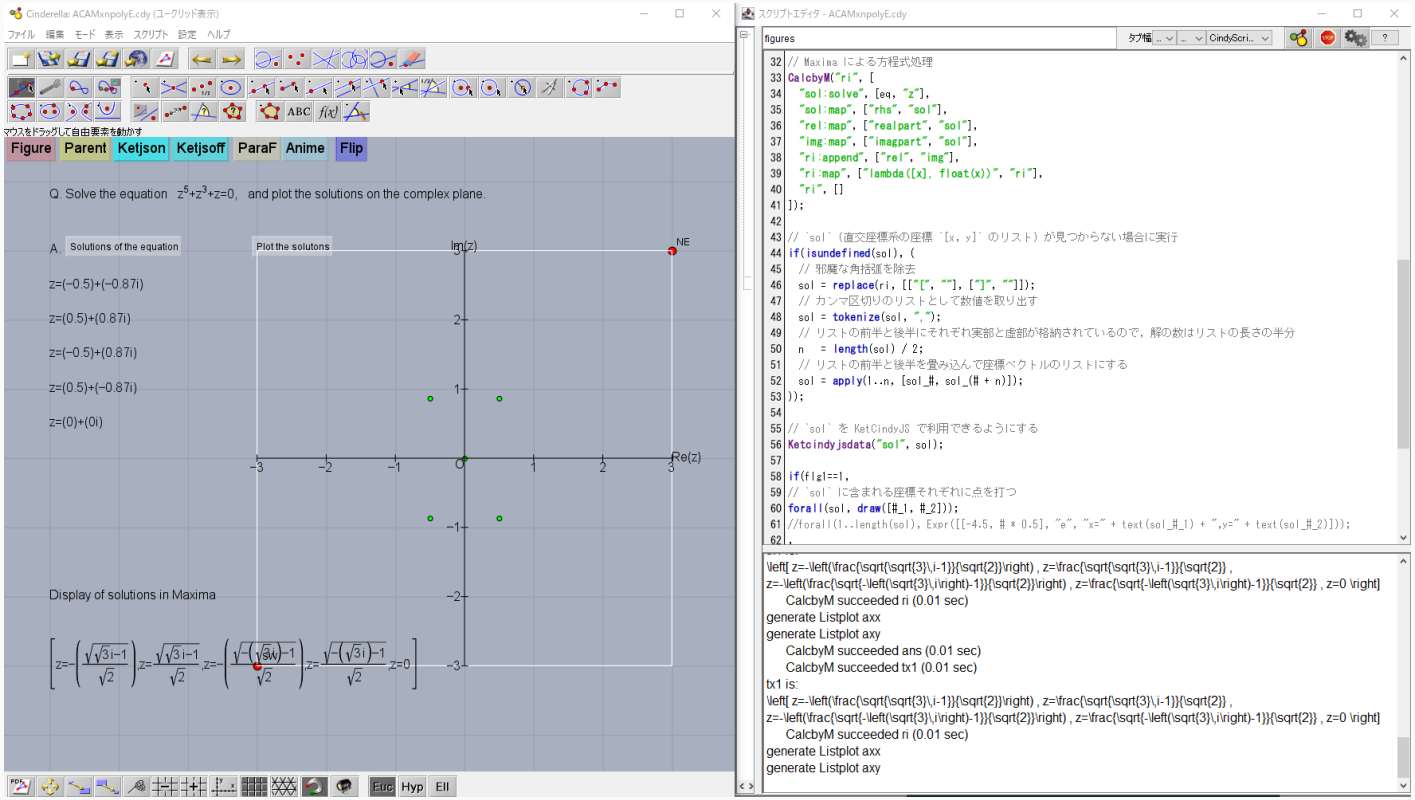


Figure 10: Cindy Script for solution of a nth-order equation

Example of teaching material 3

- envelope
  1. Find the equation of the envelope using Maxima.
  2. Draw the envelope using KeTCindy.

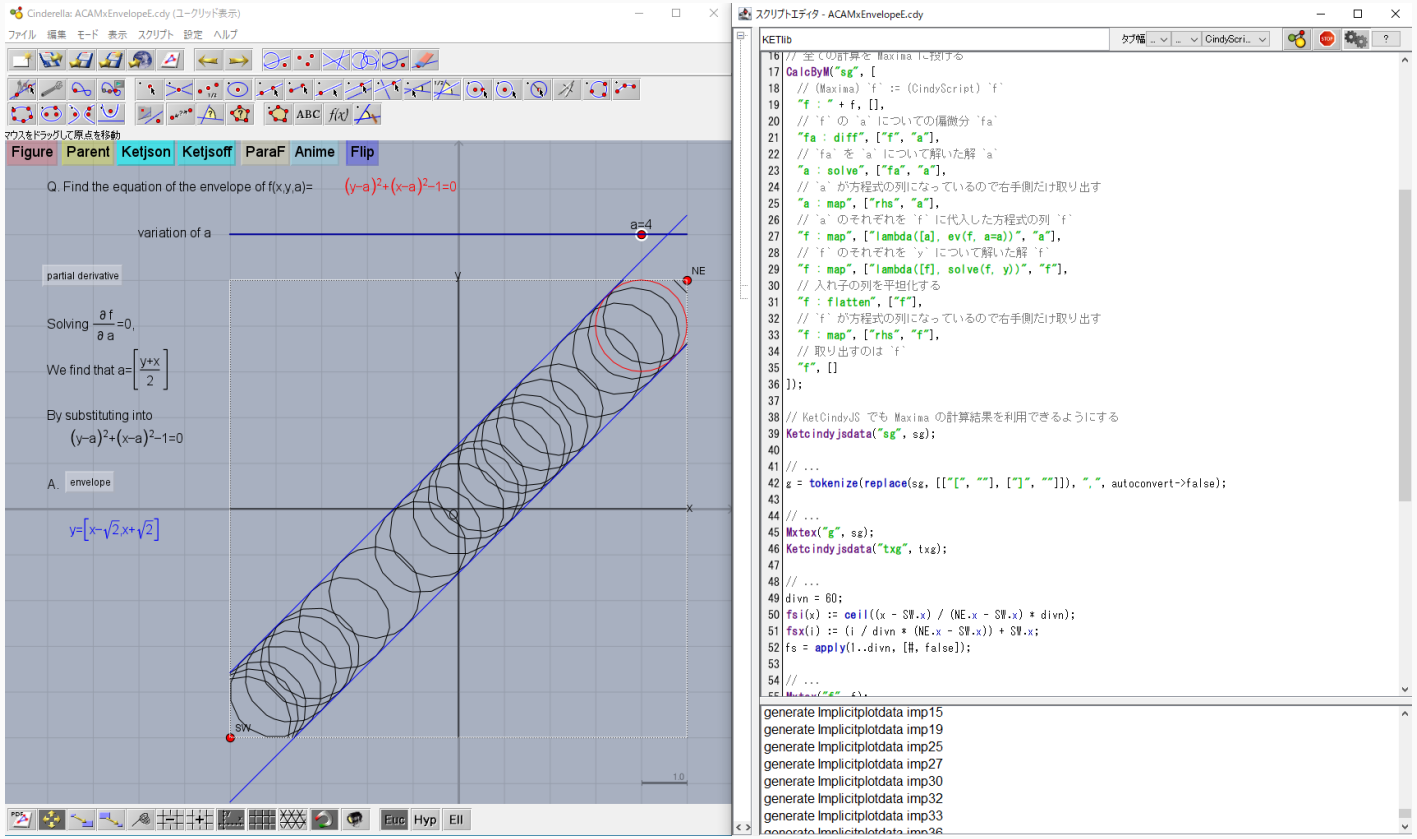


Figure 11: Cindy Script for an envelope

Example of teaching material 4

- sign chart (table of increase and decrease)
  1. Compute the first and second derivatives and find the extrema and inflection points using Maxima.
  2. Create a sign chart and draw a graph using KeTCindy.

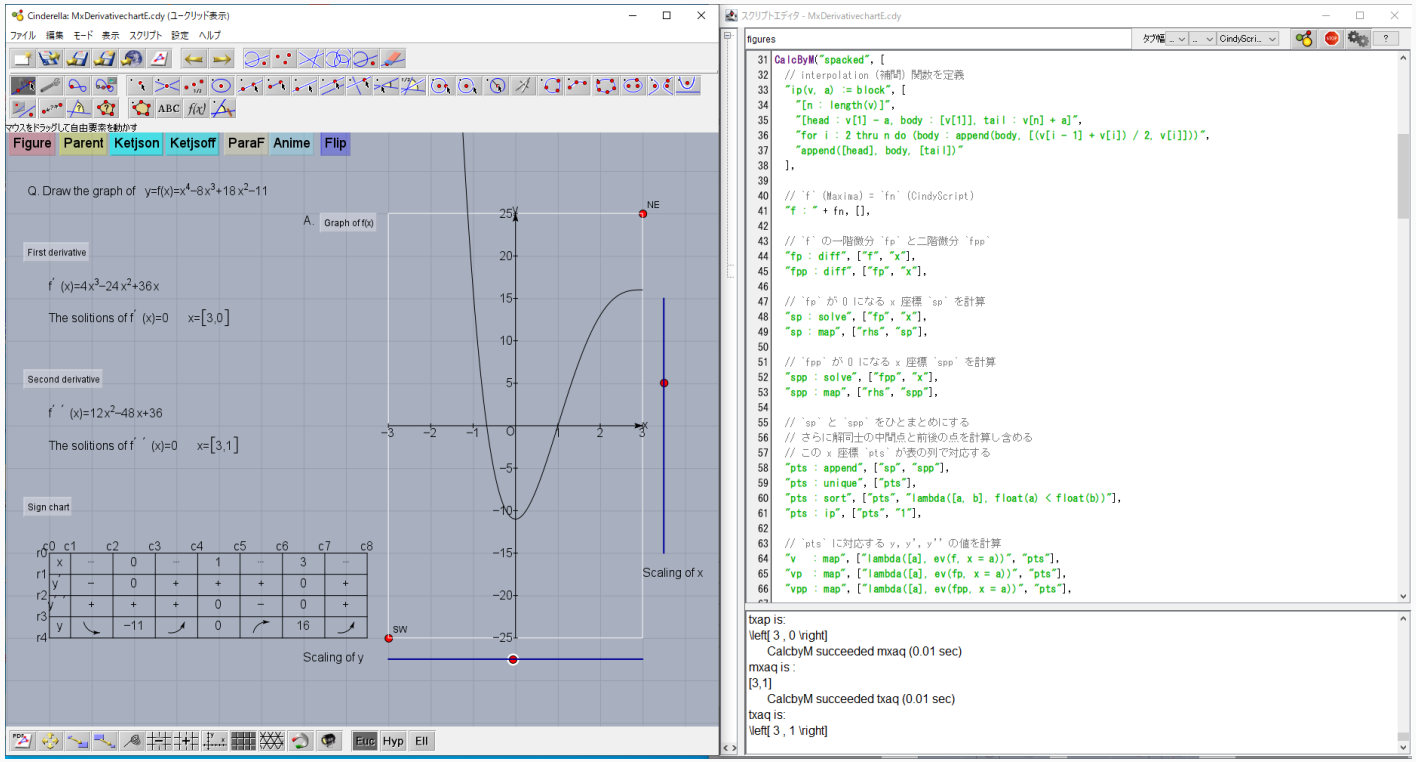


Figure 12: Cindy Script for a sign chart

Example of teaching material 5

- solution curve of a differential equation
  - Solve differential equations using Maxima.
  - Draw the solution curve using KeTCindy.

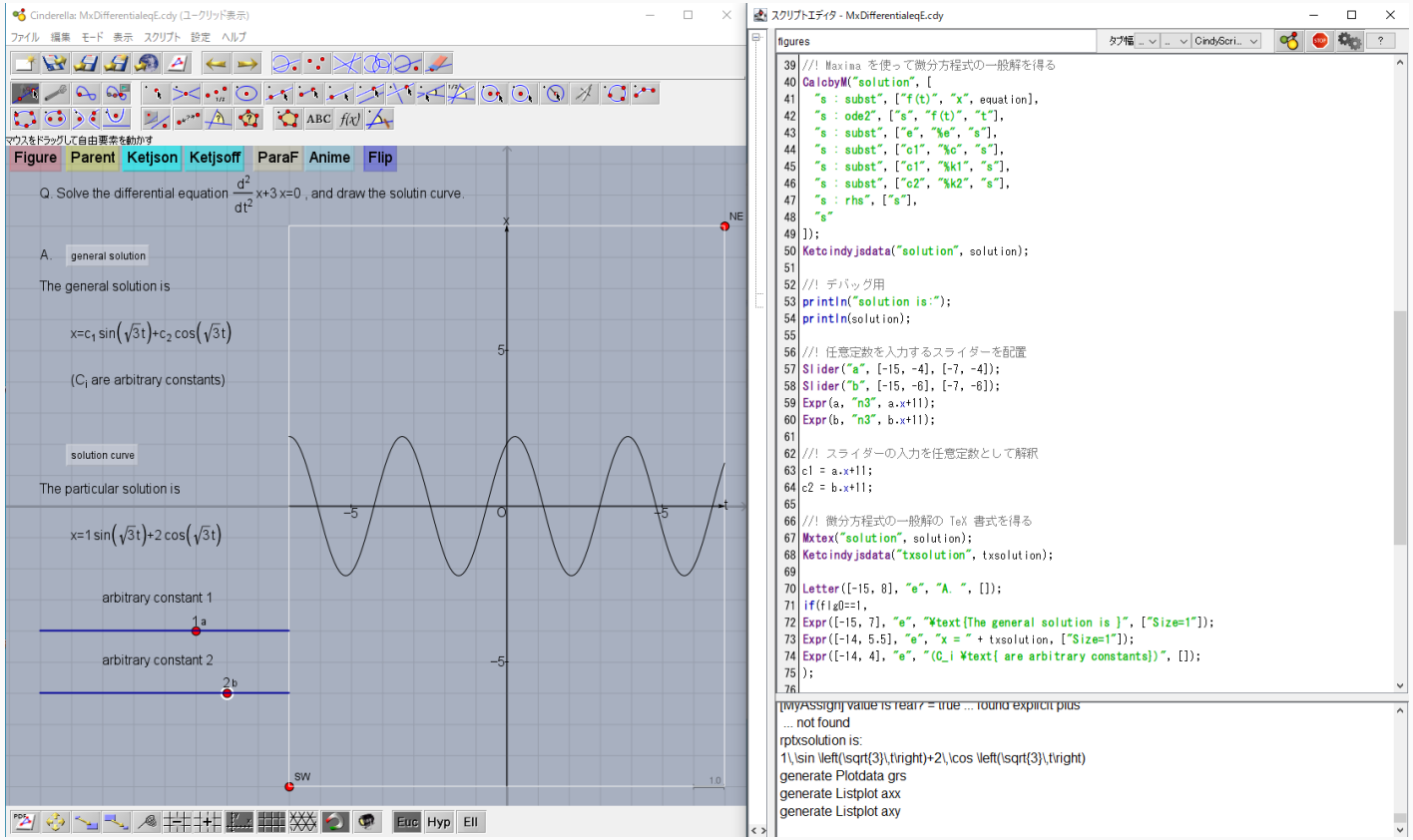
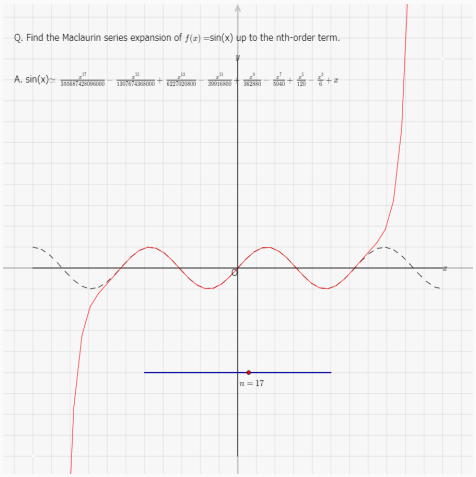
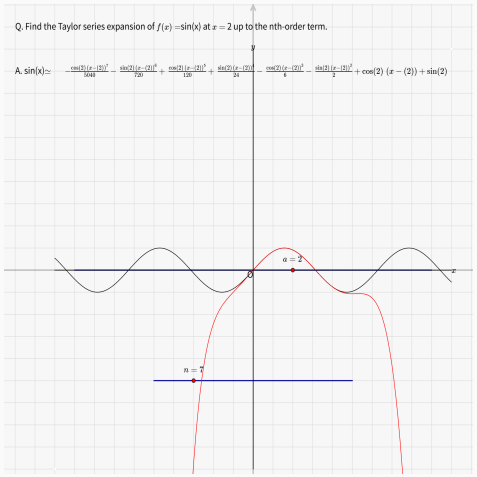


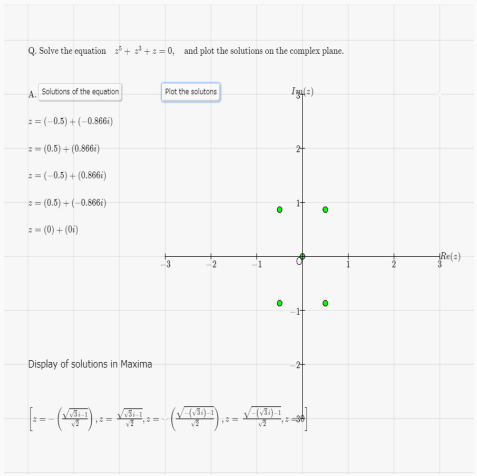
Figure 13: Cindy Script for a solution curve of a differential equation

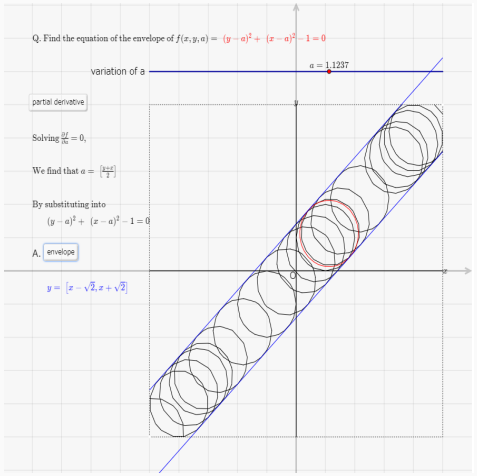
From a Cindy file to an HTML file

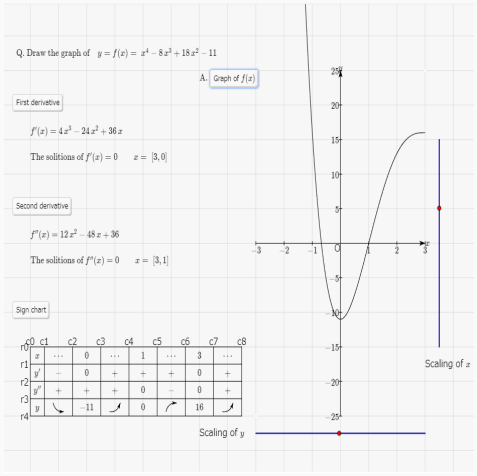
- All teaching materials
  3. Convert to an HTML file using KeTCindyJS.











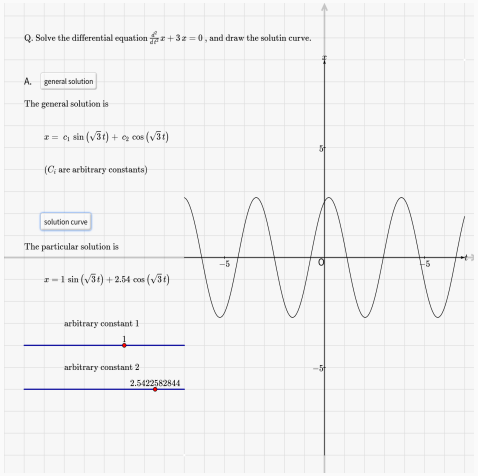


Figure 14: HTML-based teaching materials

Examples of how to use the teaching materials

- During class
  - Provides clear visual explanations.
  - The correct solution can be immediately derived even when the problem is changed.
- Online learning site
  - It's unnecessary to create a separate answer page.
    Please see the demo site below.

Figure 15: Demonstration Website for ACA2025

Conclusion

- By integrating Maxima with KeTCindyJS, symbolic computation became possible, enabling the creation of highly versatile teaching materials.
- However, offloading computations to Maxima from KeTCindyJS can sometimes result in very heavy processing.
- While it enables the creation of accurate and visually clear teaching materials, it also requires more advanced programming skills (video).
- For simple numerical computations, such as solving systems of equations, KeTCindyScript—which supports matrix and vector operations—is highly effective.
- Since KeTCindyScript is specialized for mathematics, KeTCindyJS is one of the good option for creating mathematical HTML teaching materials.

Future works

- Create new HTML teaching materials
  - Moving point problem (functions, figures, etc)
  - Integral transform (Laplace transform / Fourier transform)
  - Series expansion (Fourier series / Laurent series)
  - Problems on 3D figures
  - $\cdots$ etc.
- Set up a website as a learning platform
  By setting up the website utilizing HTML-based teaching materials as a learning platform, students become able to study independently at any time they choose.
- Cooperation of KeTCindyJS and Algebrite
  Algebrite is an algebraic computation library written in JavaScript, enabling Maxima-like operations directly in the browser.

Finish

If you're interested in today's talk, feel free to check out the site below.

Figure 16: Repository for ACA2025 presentation materials

Thank you for your attention.