AI-LearnMath:
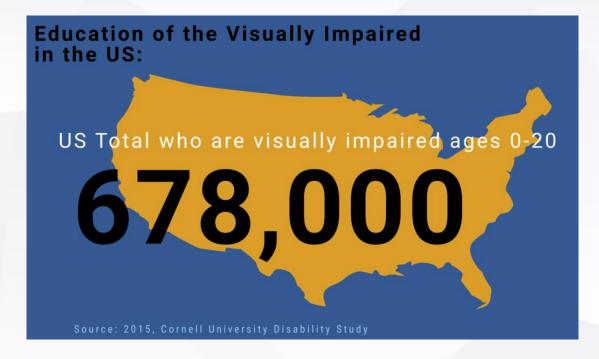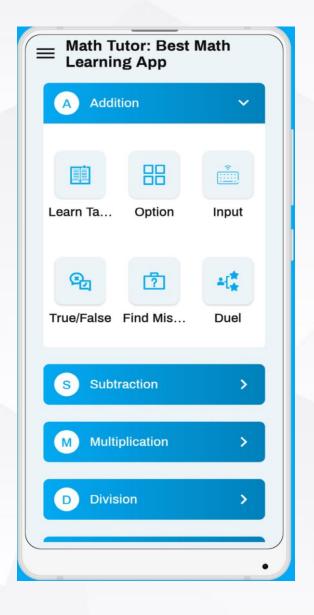An Artificial Intelligence Based Interactive Learning Platform to Assist Visually Impaired Children in Learning Mathematics

Motivation

Education of the Visually Impaired in the US:

US Total who are visually impaired ages 0-20

678,000

Source: 2015, Cornell University Disability Study

Blind and visual impaired people:

They can have great difficulties with math. They can have access issues in that their screen reader is not able to correctly read the mathematical concepts as written on a page. Vision impaired people will struggle with graphs that are color coded and with understanding what shapes and structures look like.

Math Tutor: Best Math Learning App

A Addition

Learn Ta... | Option | Input

True/False | Find Mis... | Duel

S Subtraction

M Multiplication

D Division

Problem Statement

Since new technologies have developed many softwares and platforms that help normal students learning mathematics which didn't consider students with disabilities. Thus, students with disabilities will always have difficulties keeping the same study pace of normal students. They must have some special assistances that help them improve efficiency.

In this case, we plan to conduct a research which target the solution of helping visually impaired people learning and practicing mathematics independently.

Here, we plan to adopt auditory and tactile feedback to conduct a smartphone based platform with the design of artificial intelligence. The platform will realized the functions that help visually impaired people to practice certain types of mathematical problems by themselves. Also, it will be able to assist teachers in class with introduction and explaining mathematical concepts and questions.

Previous Work

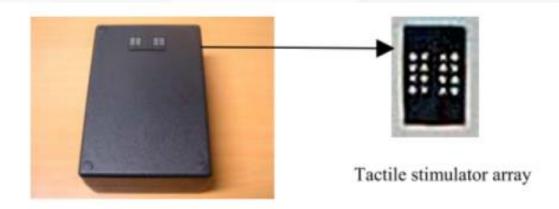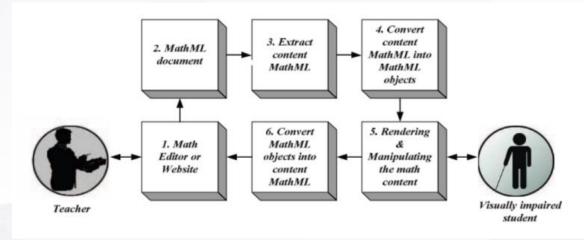Figure 1 – Braille box and tactile simulator array

Figure 2 – The MathPractice framework structure

$$\int 2x \; \cot \; 2x^2 \, dx = -\tfrac{1}{2} \ln \left| \cos \; x^2 \right| + CC \in R$$
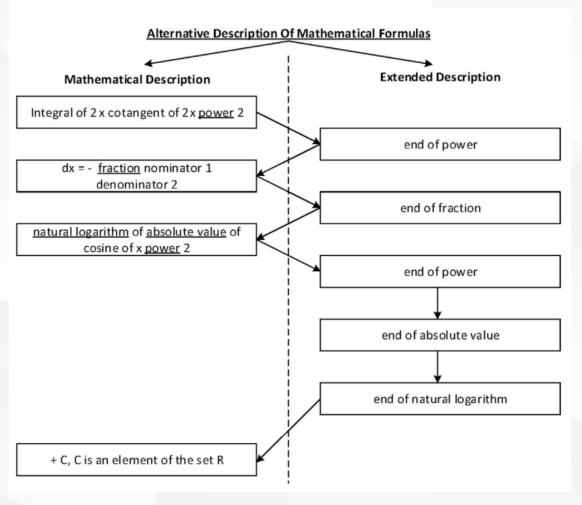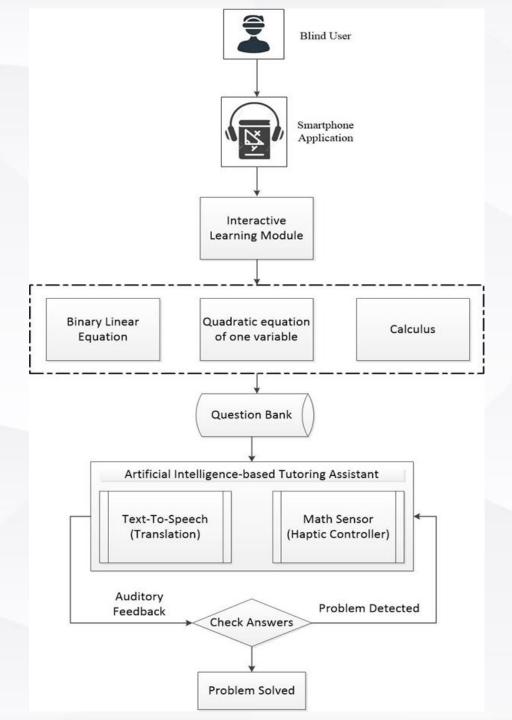
Figure 3 – The schema of alternative description of mathematical equation

Source: Sribunruangrit et al. [3], Elkabani et al. [4], Maćkowski et al. [2]

Proposed Framework

Steps for Self-practice
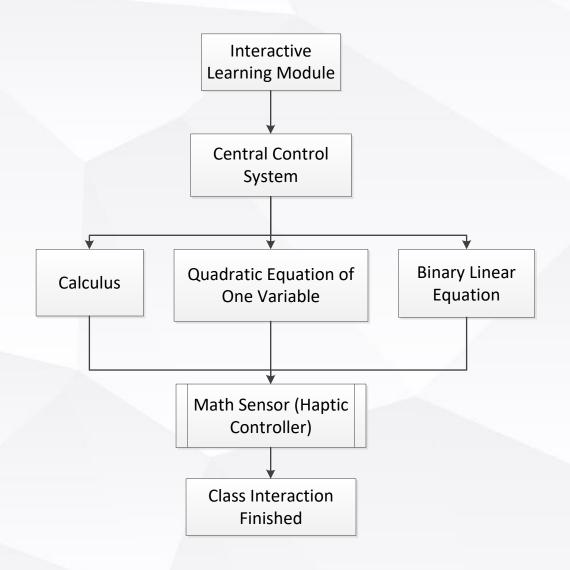
1. A pair of earphones and a haptic controller device are provided;
2. Choose types of mathematical questions through interactive learning module by voice control;
3. System automatically search questions of chosen type from the question bank;
4. Question will be analyzed in a certain way according to the specific solutions;
5. Output information from both text-to-speech device and haptic controller synchronously;
6. Visually impaired people interact with system through auditory feedback;
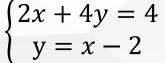7. Judge the correctness of the answer;
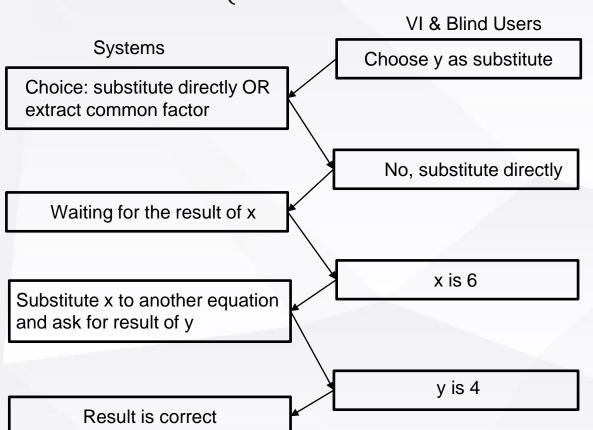
Proposed Framework

Steps for Class Interaction

1. Teachers will be able to design their own questions and input into the system.
2. Teacher spread questions uniformly through central control system;
3. Student will accept their question and upload their test-taking process, so that teachers can monitor the performance of the students and give right response.
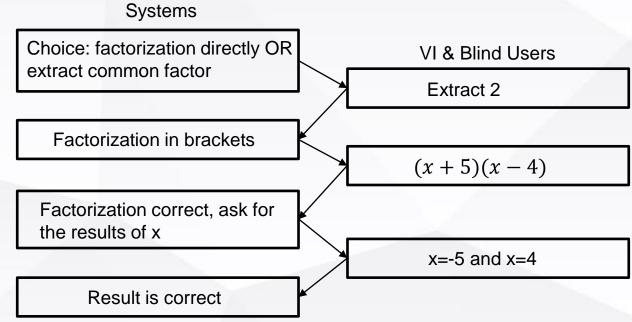
Mathematical Problem Solution

Solution for Systems of Linear Equation

$$\begin{cases} 2x + 4y = 4 \\ y = x - 2 \end{cases}$$

Systems

| Choice: substitute directly OR extract common factor |

VI & Blind Users

| Choose y as substitute |

| No, substitute directly |

| Waiting for the result of x |

| x is 6 |

| Substitute x to another equation and ask for result of y |

| y is 4 |

| Result is correct |

Solution for Quadratic Equation of One Variable

$$2x^2 + 2x - 40 = 0$$

Systems

| Choice: factorization directly OR extract common factor |

VI & Blind Users

| Extract 2 |

| Factorization in brackets |

| $(x + 5)(x - 4)$ |

| Factorization correct, ask for the results of x |

| x=-5 and x=4 |

| Result is correct |

Mathematical Problem Solution

Solution for Simple Derivative $f(x) = 3x^2 + 4x, what\ is\ f'(x)?$

Systems

What is the coefficient of the derivative of first item

VI & Blind Users

The coefficient is 6

What is the power of the derivative of first item

The power is 1

What is the coefficient of the derivative of second item

The coefficient is 4

What is the power of the derivative of second item

The power is 0

Result is correct, the derivative is $f'(x) = 6x + 4$

Text-To-Speech

Text-To-Speech Solution

Haptics

Figure – How to read & write Braille
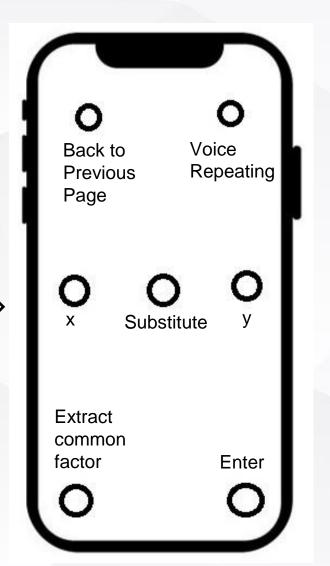
Braille is an universal language for blind or visually impaired people. But for mathematical learning, we can make it to be more vivid.

Proposed Haptics Solution

Solution for Systems of Linear Equation

$$\begin{cases} 2x + 4y = 4 \\ y = x - 2 \end{cases}$$

Proposed Haptics Solution

Solution for Quadratic Equation of One Variable
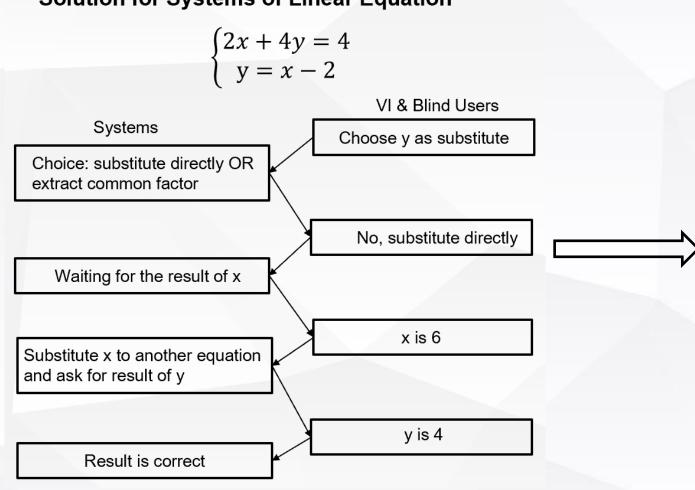
$$2x^2 + 2x - 40 = 0$$

Systems

Choice: factorization directly OR extract common factor

Factorization in brackets

Factorization correct, ask for the results of x

Result is correct

VI & Blind Users

Extract 2

$(x + 5)(x - 4)$

x=-5 and x=4

Back to Previous Page

Voice Repeating

x   Factorization   y

Extract common factor

Enter

Proposed Haptics Solution

Solution for Simple Derivative $f(x) = 3x^2 + 4x, what\ is\ f'(x)?$

Systems

What is the coefficient of the derivative of first item

What is the power of the derivative of first item

What is the coefficient of the derivative of second item

What is the power of the derivative of second item

Result is correct, the derivative is $f'(x) = 6x + 4$

VI & Blind Users

The coefficient is 6

The power is 1

The coefficient is 4

The power is 0

Back to Previous Page

Voice Repeating

power

coefficient

Enter

Proposed Solution for Result Input

Enter Braille as Solution

BRAILLE ALPHABET
ENGLISH VERSION

Proposed Solution for Result Input

Voice Recognition as Solution (Speech-to-Text)

This is a demo of speech-to-text module, $2x^2 + 2x - 40 = 0$

1. Watson
2. Google Cloud
3. Microsoft Azure

Voice Model:

US English broadband model (16KHz) ▼

Keywords to spot:

IBM,admired,AI,transformations,cognitive,Artificial Intelligence,da

☐ Detect multiple speakers

🎤 Record Audio | ⬆ Upload Audio File | ▶ Play Sample 1 | ▶ Play Sample 2

Text | Word Timings and Alternatives | Keywords (0/9) | JSON

This is a demo of. These 2 attacks module. Multiplied by X. squared plus 2 X. minus 40 equal 0.

Proposed Solution for Result Input

Voice Recognition as Solution (Speech-to-Text)

1. Watson
2. Google Cloud
3. Microsoft Azure

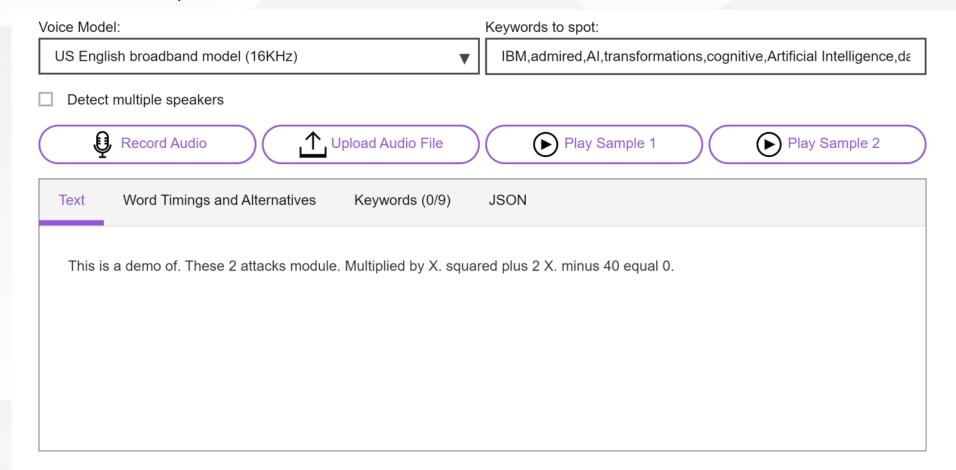This is a demo of speech-to-text module, $2x^2 + 2x - 40 = 0$

Proposed Solution for Result Input

Voice Recognition as Solution (Speech-to-Text)

This is a demo of speech-to-text module, $2x^2 + 2x - 40 = 0$

1. Watson
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3. Microsoft Azure

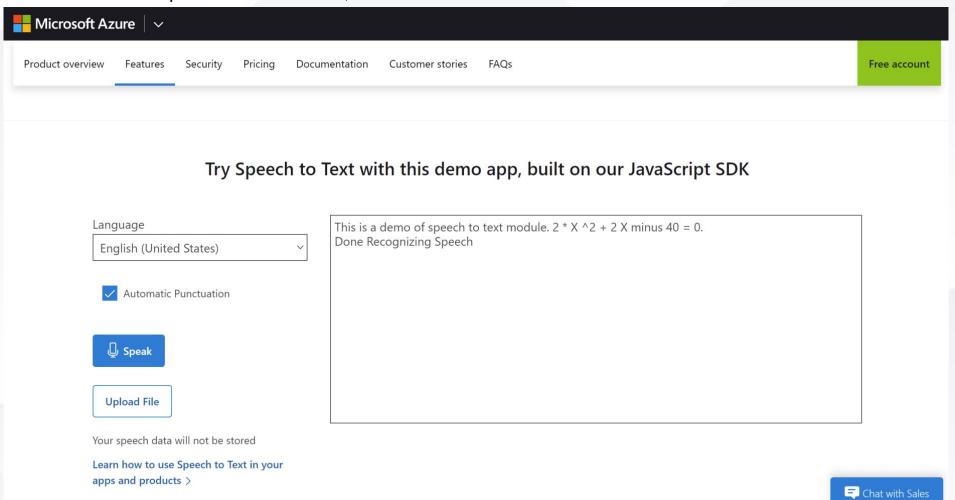**Microsoft Azure** ⌄

| Product overview | Features | Security | Pricing | Documentation | Customer stories | FAQs | | Free account |

Try Speech to Text with this demo app, built on our JavaScript SDK

Language

English (United States) ⌄

☑ Automatic Punctuation

🎤 Speak

Upload File

Your speech data will not be stored

Learn how to use Speech to Text in your apps and products >

> This is a demo of speech to text module. 2 * X ^2 + 2 X minus 40 = 0.
> Done Recognizing Speech

💬 Chat with Sales

Designed Experiment

The targeted experiment participants are middle school students who are visually impaired or blind.

We plan to distribute the software to those students and keep them practicing these three types of mathematical problems for one week with the assistance of AI-LearnMath. An evaluation will be designed to assess the performance of students on the improvement of mathematics compared with the control group, students of which will maintain their study plan using normal teaching techniques. Beside, we need to conduct an interview to investigate the satisfaction of the students to the proposed platform.

In addition, the software will also be tested in class. In this case, we may need teachers to cooperate with our experiments. An interview will be designed for teachers to evaluate the accessibility of software as well as its efficiency.

The results will be organized in form of tables, bar charts, and interview lists.

Expected Results

We expect to foresee the result of improvement of our proposed platform, to an extent that can help to enhance the efficiency of learning mathematics for visually impaired or blind students.

On the other hand, we assumes the combination of auditory and tactile feedback with the help of interactive platform will also intrigue students' interests in learning mathematics.

At the last, teachers will also get more conveniences to teach students learning mathematics.

Future Work

1. Question bank can be enlarged to give plentiful and more diverse practice questions.

2. More mathematical question types can be explored to make the whole system to be more universal.

3. We may decide to explore the feasibility of connecting the external tactile device that interact with the visually impaired or blind users through braille.

4. To make the interaction more intelligent, we can refer some previous works like adaptive auditory feedback to make the interaction more smooth.

Reference

[1] Spinczyk, Dominik, et al. "Factors Influencing the Process of Learning Mathematics among Visually Impaired and Blind People." *Computers in Biology and Medicine 104 (2019): 1-9. Print.*

[2] Maćkowski, Michał Sebastian, Piotr Franciszek Brzoza, and Dominik Roland Spinczyk. "Tutoring Math Platform Accessible for Visually Impaired People." Computers in Biology and Medicine 95 (2018): 298-306. Print.

[3] Graphic-User-Interface System for People with Severely Impaired Vision in Mathematics Class. The 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. 1-5 Sept. 2004 2004. Print.

[4] A Framework for Helping the Visually Impaired Learn and Practice Math. 2015 5th International Conference on Information & Communication Technology and Accessibility (ICTA). 21-23 Dec. 2015 2015. Print.

[5] Shoaib, M., Hussain, I., & Mirza, H. T. (2019). Automatic switching between speech and non-speech: adaptive auditory feedback in desktop assistance for the visually impaired. Universal Access in the Information Society, 1-11.

Thank You!