

Applications of Self-Adaptive Computational Methods in Online Learning

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Outline

- 1 Online Learning
- 2 Automatically Generated Examples
- 3 Self Adaptive Computational Methods
- 4 Motivation
- 5 Conclusions

Online Learning

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TA Homework

	<input type="button" value="Return to my homepage"/>
Username:	ta
First Name:	Andrew
Last Name:	Pownuk
Group:	2018-Spring-MATH-4329-CRN-24656
	<input type="button" value="Logoff"/>

Number of homework: 12

homework-description	Homework 13
homework-id	Homework-13
link	homework/Homework-13.aspx
tries-max	10

Response system

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- Sharing the lecture notes.
- Interactive platform for doing online homework.
- Automated system for checking attendance.
- Integrated response system.
- Grades management system.
- Interactive projects.

Response system

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Quiz

	Return to the main page
Username:	anpovrasik
First Name:	Andrew
Last Name:	Povrasik
Group:	2018-Spring-MATHS-1411-CRN-24655
	Logout

Quiz id: quiz-14 Refresh quiz info (clear answer)

Answer:	I do not know
---------	---------------

Submit answer

Your answer was submitted

I do not know

Check grade 100

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student 16		0	
student 17		0	
student 18	I do not know	0	100
student 19		0	
student 20		0	
student 21		0	
student 22		0	
student 23		0	
student 24		0	
student 25		0	
student 26		0	
student 27		0	
student 28		0	
student 29		0	
student 30		0	
student 31		0	
student 32		0	
student 33	I have no idea	0	100
student 34		0	
student 35		0	

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	2/13/2018	quiz-8		2/13/2018	quiz-9		2/13/2018	quiz-10		2/13/2018
	2/13/2018	quiz-8		2/13/2018	quiz-9		2/13/2018	quiz-10		2/13/2018
100	2/13/2018	quiz-8	100	2/13/2018	quiz-9	100	2/13/2018	quiz-10	100	2/13/2018
100	2/13/2018	quiz-8		2/13/2018	quiz-9	100	2/13/2018	quiz-10	100	2/13/2018
	2/13/2018	quiz-8		2/13/2018	quiz-9	100	2/13/2018	quiz-10	100	2/13/2018
100	2/13/2018	quiz-8	100	2/13/2018	quiz-9	100	2/13/2018	quiz-10	100	2/13/2018
100	2/13/2018	quiz-8		2/13/2018	quiz-9	100	2/13/2018	quiz-10	100	2/13/2018
	2/13/2018	quiz-8		2/13/2018	quiz-9		2/13/2018	quiz-10		2/13/2018
100	2/13/2018	quiz-8	100	2/13/2018	quiz-9	100	2/13/2018	quiz-10	100	2/13/2018

Is it possible to create automated thinker?

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Sample assignment (simplify the expression)

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$$0$$

$$1 - 1$$

$$(1 - 1) * (1 - 1)$$

$$(1 - 1) * (1 - 1) * 5$$

$$(1 - 1) * (1 - 1) * 5 * \frac{7}{2}$$

$$(1 - 1) * \left(\frac{3}{3} - 1\right) * 5 * \frac{7}{2}$$

$$\left(1 - \frac{99}{99}\right) * \left(\frac{3 + (1 - 1) * \left(\frac{3}{3} - 1\right) * 5 * \frac{7}{2}}{3} - 1\right) * 5 * \frac{7}{2}$$

Sample assignment (find integral)

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$$7x + 5$$
$$7 \left(\frac{x^2}{2} \right)' + 5(x)'$$

$$\left(7 \frac{x^2}{2} + 5x + C \right)'$$

$$\int (7x + 5) dx = 7 \frac{x^2}{2} + 5x + C$$

Sample assignment (find derivative)

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$$((3x + 1) * (5x + 7))'$$

$$(3x + 1)' * (5x + 7) + (3x + 1) * (5x + 7)'$$

$$3 * (5x + 7) + (3x + 1) * 5$$

Sample assignment (calculate the limit)

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$$\lim_{x \rightarrow \infty} \frac{5x^2 + 2x + 1}{x^2 + 1}$$

$$\lim_{x \rightarrow \infty} \frac{\frac{5x^2 + 2x + 1}{x^2}}{\frac{x^2 + 1}{x^2}}$$

$$\lim_{x \rightarrow \infty} \frac{5 + \frac{2}{x} + \frac{1}{x^2}}{1 + \frac{2}{x^2}}$$

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Set theory

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$$A \cup B = B \cup A$$

$$A \cap A^C = \emptyset$$

$$(A \cup B) \cap (B \cup A)^C = B \cap B^C$$

$$((A \cup B) \cap (B \cup A)^C) \cap ((A \cup B) \cap (B \cup A)^C)^C = \emptyset$$

etc.

Probability theory

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$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

$$P(A|B)P(B) = P(A \cap B)$$

$$P(A \cup B) = P(A) + P(B) - P(A|B)P(B)$$

etc.

Analysis

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$$\frac{d}{dx} \left(EA \frac{du}{dx} \right) + n = 0, u(0) = 0, u(L) = 0$$

$$\int_0^L \frac{d}{dx} \left(EA \frac{du}{dx} \right) v dx + \int_0^L n v dx = \int_0^L 0 v dx, u(0) = 0, u(L) = 0$$

$$\int_0^L u \frac{dv}{dx} dx = \int_0^L \frac{du}{dx} v dx + u(0)v(L) - u(L)v(0)$$

$$\int_0^L \frac{d}{dx} \left(EA \frac{du}{dx} \right) v dx = \int_0^L EA \frac{du}{dx} \frac{dv}{dx} dx + EA \frac{du(0)}{dx} v(0) - EA \frac{du(L)}{dx} v(L)$$

etc.

Fundamental theorem of Galois theory.

Number of automorphisms equals the degree of the extension.

$$|Gal(K/F)| = [K : F]$$

Field extension K/F .

Degree of the extension $[K : F]$.

Number of automorphisms in the Galois extension $|Gal(K/F)|$.

For example, if we know that

$6 = [K : F] = [\mathbb{Q}(\sqrt[3]{2}, \sqrt{-3}) : \mathbb{Q}]$, then we know instantly
that $6 = |Aut(K/F)| = |Aut(\mathbb{Q}(\sqrt[3]{2}, \sqrt{-3})/\mathbb{Q})|$ etc.

Lagrange Theorem.

- Function $f(x)$ is continuous in the interval $[a, b]$
- Function $f(x)$ is differentiable in the interval (a, b)

then exists $c \in (a, b)$ such that $\frac{f(b)-f(a)}{b-a} = f'(c)$

- Function $f(x)g(x)$ is continuous in the interval $[a, b]$
- Function $f(x)h(x)$ is differentiable in the interval (a, b)

then exists $c \in (a, b)$ such that

$$\frac{f(b)g(b)-f(a)h(a)}{b-a} = f'(c)g(c) + f(c)g'(c)$$

Programming

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```
int f(int x)
{
    return x*x;
}
```

$f(f(x))$

```
int ff(int x)
{
    return (x*x)*(x*x);
}
```

Natural Language

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Input information:

I like Las Cruces.

Output information:

I like a city 40 miles from El Paso.

Output information:

I like a place with a lot of houses and roads 40 miles from El Paso.

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Product rule (input information)

$$(f * g)' = f' * g + f * g'$$

After calculations (new theorem created automatically)

$$(f * g * h)' = f' * g * h + f * g' * h + f * g * h'$$

New theorem can be used in exactly the same way like the original theorem.

System of linear equations

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Regular student has a lot of problems with solution of a system of equations with more than 5 equations.

By using computational methods it is possible to solve millions of equations.

Integration/differentiation

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Regular student has a lot of problems finding the solutions of the typical problems from the calculus I and II textbook.

By using computational algebra system it is possible to solve millions of integrals in reasonable time.

AlphaGo

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AlphaGo's 4-1 victory in Seoul, South Korea, in March 2016 was watched by over 200 million people worldwide. It was a landmark achievement that experts agreed was a decade ahead of its time, and earned AlphaGo a 9 dan professional ranking (the highest certification) - the first time a computer Go player had ever received the accolade.

Google's AlphaZero

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December 6, 2017

Google's AlphaZero defeated Stockfish in 100-game match.
Alpha Zero won the match with 28 wins, 72 draws and 0 lose.

Conclusions

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- By using presented methodology it is possible to create complex educational examples in many areas of mathematics as well as in other areas of science and engineering.
- In a few minutes it is possible to create thousands pages with typical examples that can be used in education.
- By using self adaptive computational methods it is possible to automatically generate new mathematical theorems completely independently from human interactions.