

# Recursive Recognition of Offline Handwritten Mathematical Expressions

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#### Problem

Given an image depicting a mathematical expression decode it in a symbolic representation

 $x = \frac{1}{2} \text{ m} + 2 \text{ m}$   $x = \frac{1}{2} \text{ m} + 2 \text{ m}$ Output symbols

More challenging that conventional OCR!

- non-sequential spatial layout
- · little prior information from language models
- unknown trajectory of the pen (offline recognition)

## Data

9100 photos of expressions written by more than 100 volunteers and including 99 different symbols

$0.1.1 + y + 3q^2$	$\frac{2}{2} - \frac{\lfloor b \rfloor - 3}{k \cdot B}$
W: 1031	$\begin{bmatrix} y_{+k+x} \\ z_{-I-bx} \end{bmatrix}$
3:8 : 528	$3 > \chi + 6 + \frac{5}{\emptyset}$
yA+b-y+b	$ n-F  \neq I-j \neq c-1$
p.io	8 ~ ≪√(d)
5+1+x·3	h÷M:a:40-X-2B+Y
ez: Txd	Vm·5-2+03:3



## Results

Accuracy (%)
90.7
95.2
95.0
96.7
94.6
96.4
98.4
94.7
100.0
96.2
84.2

## **Errors**

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Errors typically occurs for low-quality images and badly written expressions

+2×94	JK-14- 11=2
<u>9+2-3÷π</u> ≥ 3N×Y·0·n-6	10+6) ×A +V+R-B +[3+6]
$\sqrt{X} \leqslant \sqrt[4]{1 \times 0}$	<u>(22×K)×K+2-75</u> : +71 M
A - X : 3. C - 0	(1-e×W)+i+r×m). K-g×J+0××
Stot Fat m	1+.1 xj = K af+ v

## Method

A CNN extracts image features, a RNN decode symbols, a deconvolutional module segments subexpressions