OCR-Based Autograder for Handwritten Content

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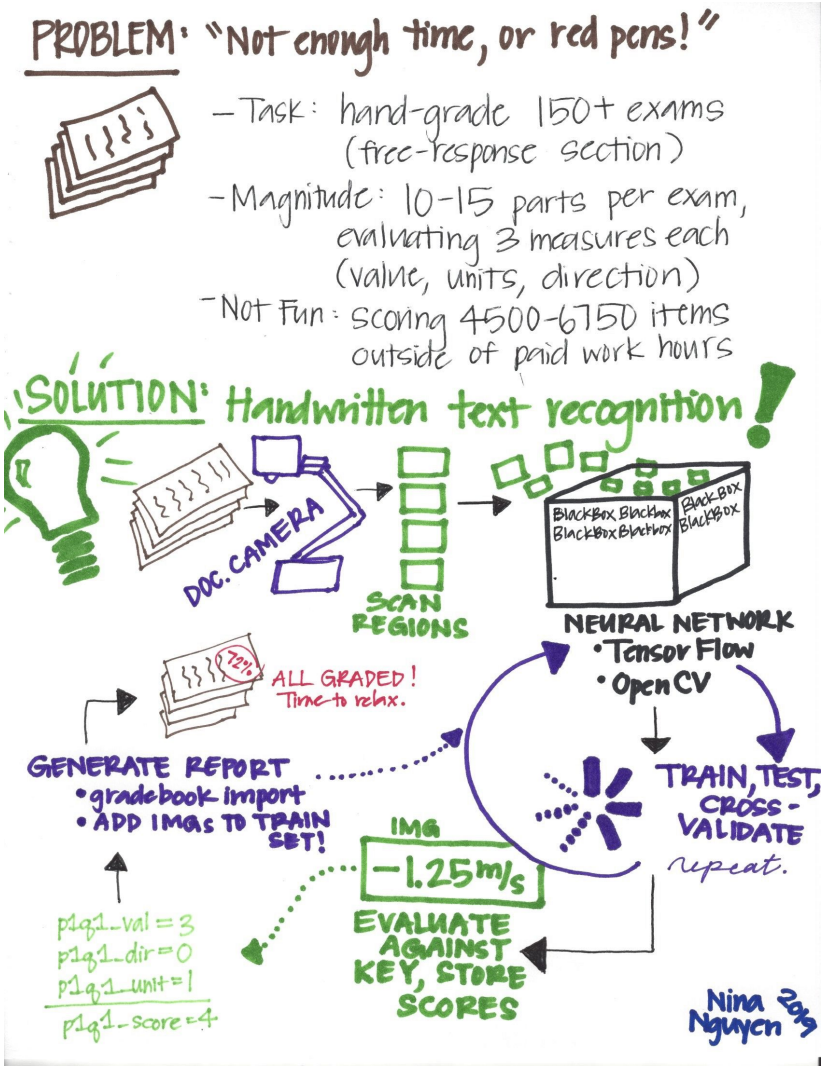
The Problem

Hand grading free-response questions for physics and math is a pain.

It is a monotonous process that can be automated due to limited characters and symbols, unlike English/history.

Why should a human do this when a computer can?

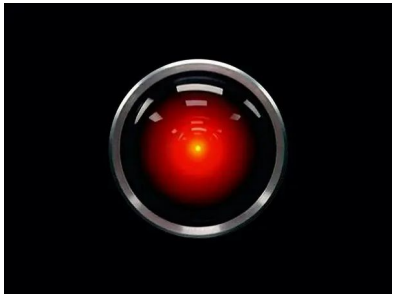


Inspiration

Illuminate has rendered ScanTron obsolete with OCR grading.

Key Features:

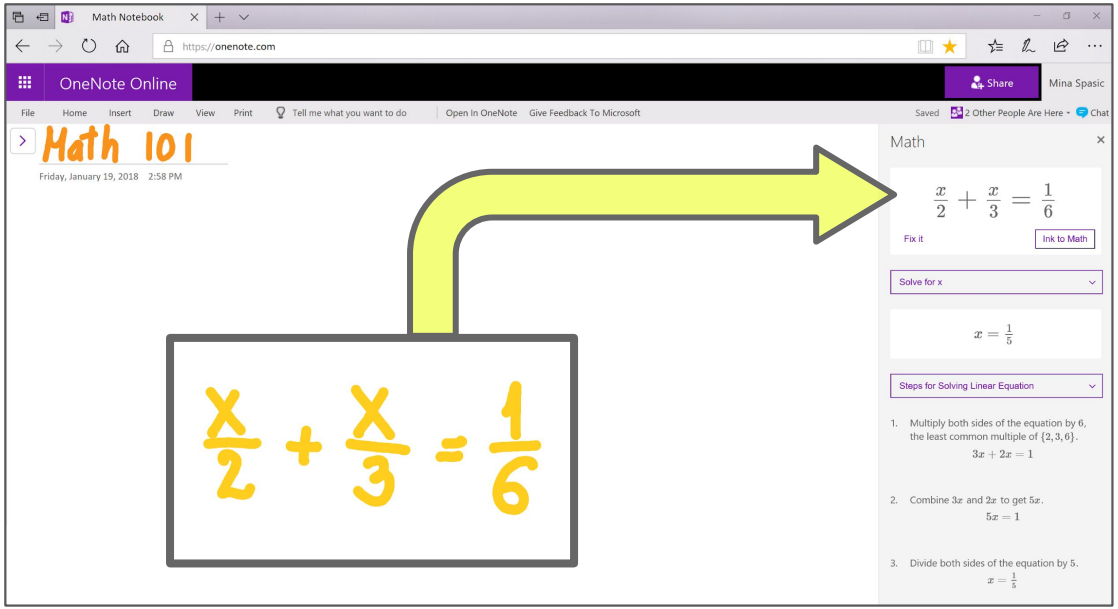
- Test-specific forms
- Automatic gradebook entry
- Doc cam or webcam

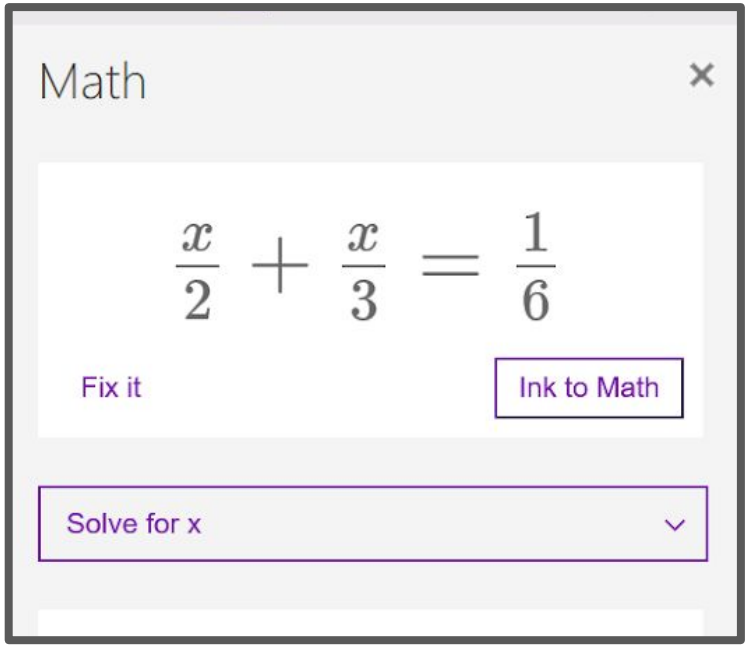


illuminate education

Ink-spiration

Penstroke recognition by Microsoft





OneNote

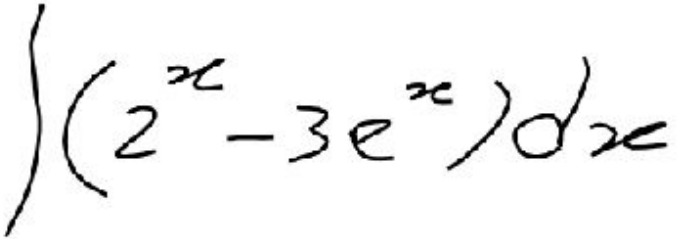
Windows Ink

General Process

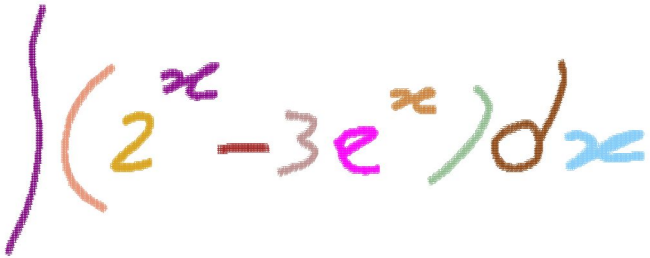
0) Convert InkML to .png

InkML is a XML data type for digital ink data obtained from an electronic pen or stylus.

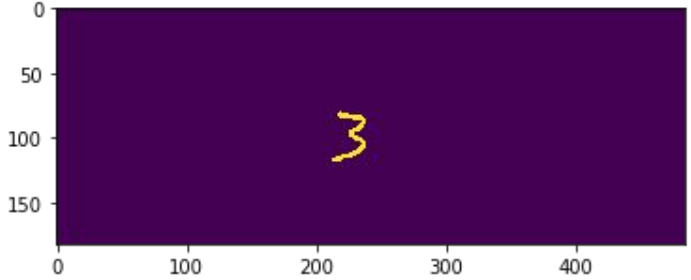
1) Raw Image



2) Segmentation



3) Object isolation/processing

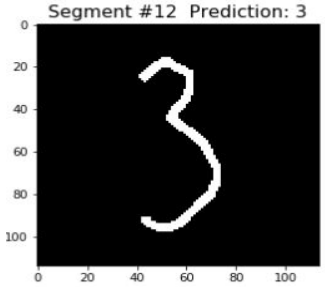


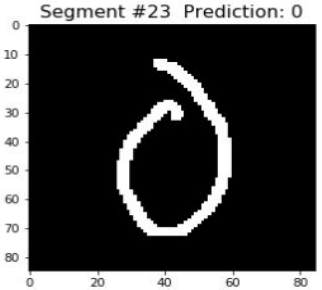
Segmentation Challenges

How many segments do you see?

$$\begin{pmatrix} 3 & 0 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 0 & -1 \end{pmatrix}^{-1} \begin{pmatrix} 3 & 2 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 1 \\ 0 & -1 \end{pmatrix}$$

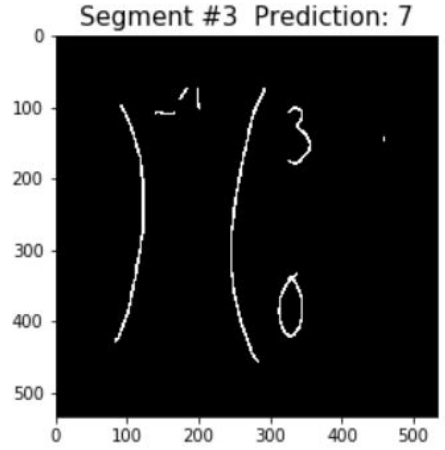
As expected, we get:

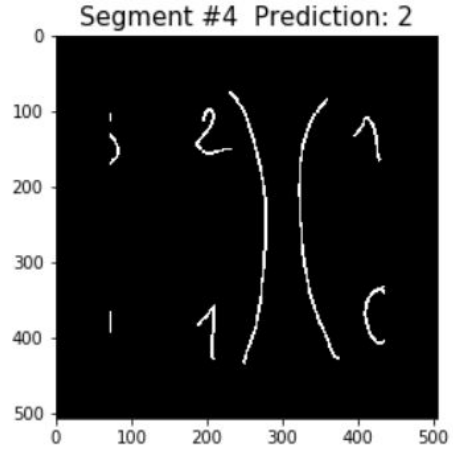




and so on...

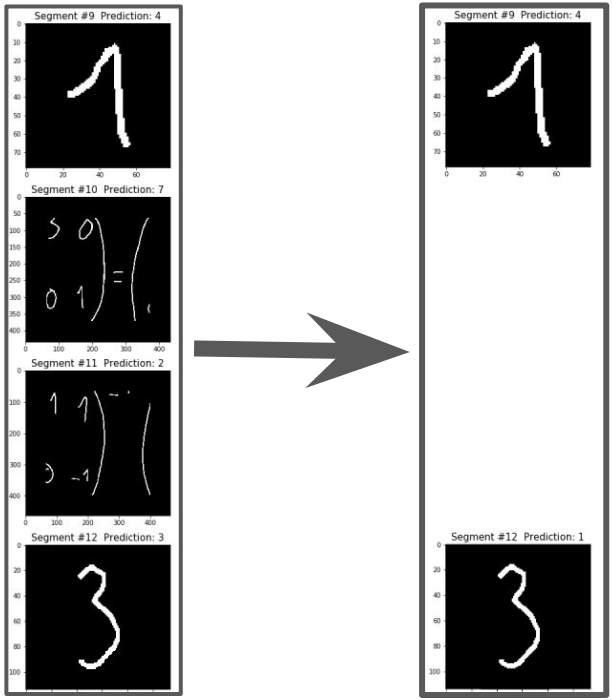
.....But wait, there's more!

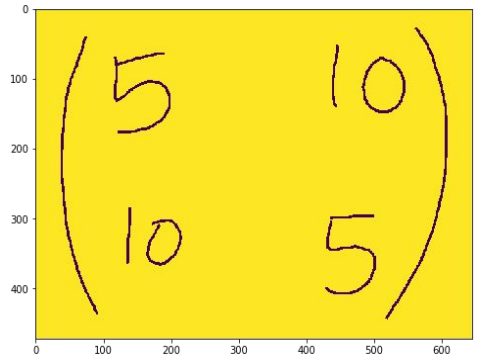


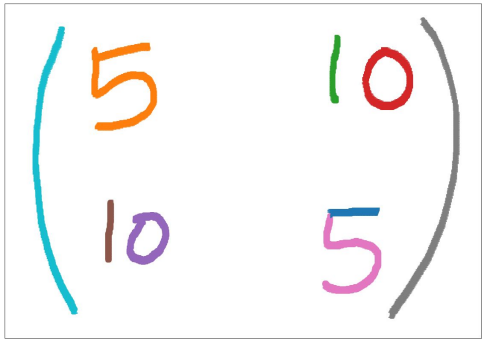


Segmentation Challenges

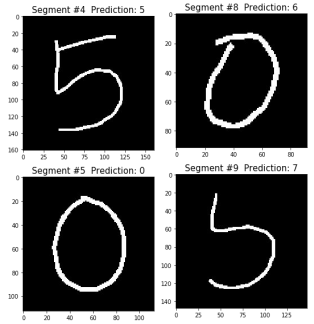
Write code to ignore such segments before isolation.







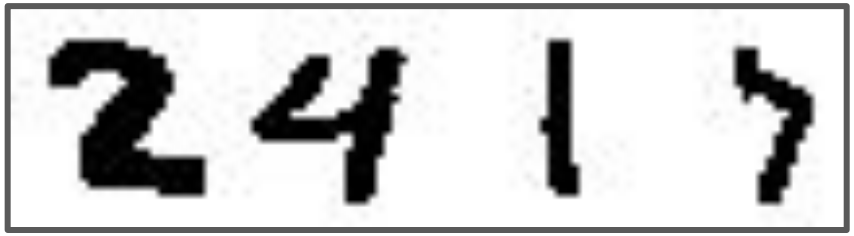
...which helps most things,
but can cause other issues.



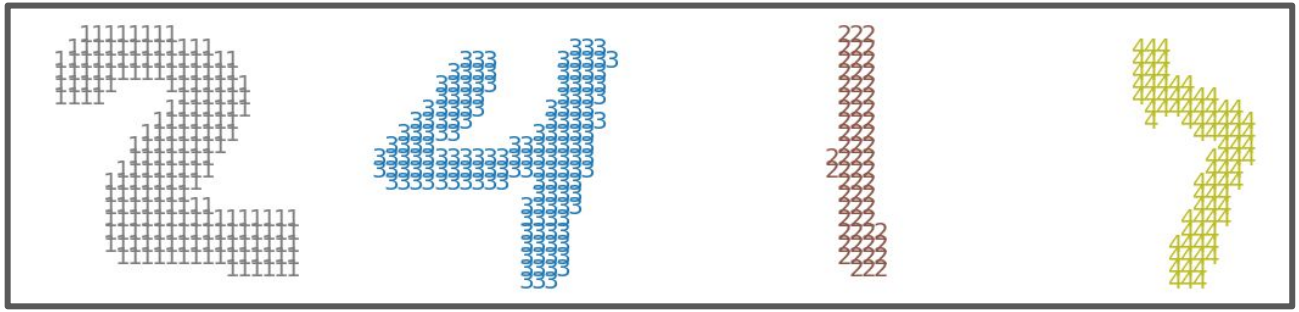
Simplify the Problem at Hand: Generate Test Images

Process

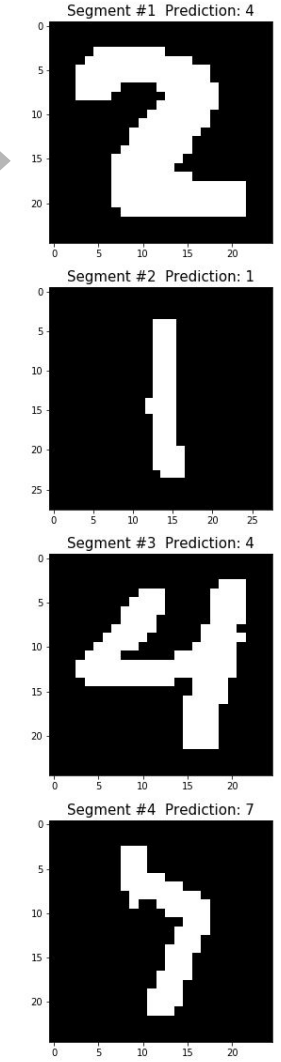
1) Raw Image Creation



2) Segmentation



3) The Fun Part
   a) Isolate objects
   b) Make square (non-trivial task)
   c) Resize to 28x28
   d) Make individual predictions



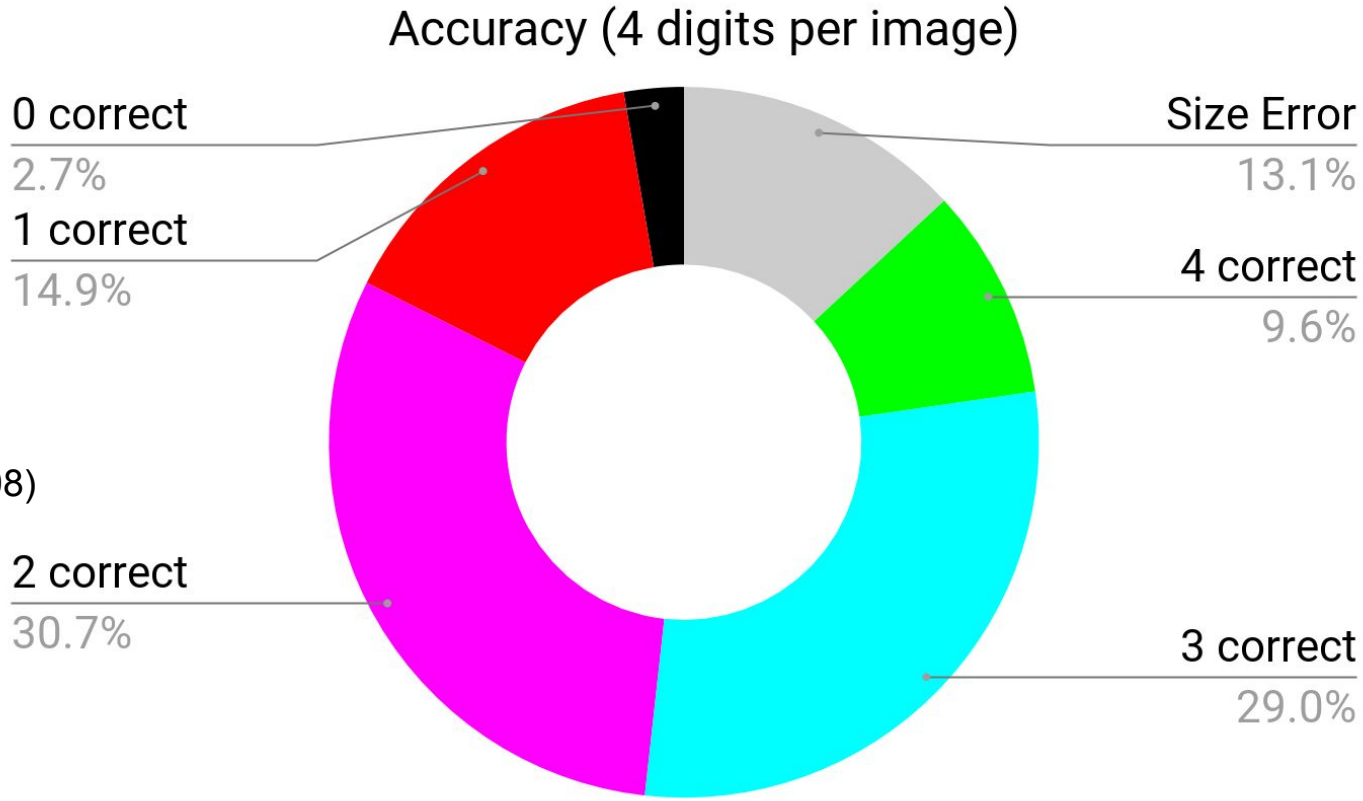
Decision Tree Classifier

17,500 images

Accuracy (on 15,208)

Mean: 0.580

SD: 0.246



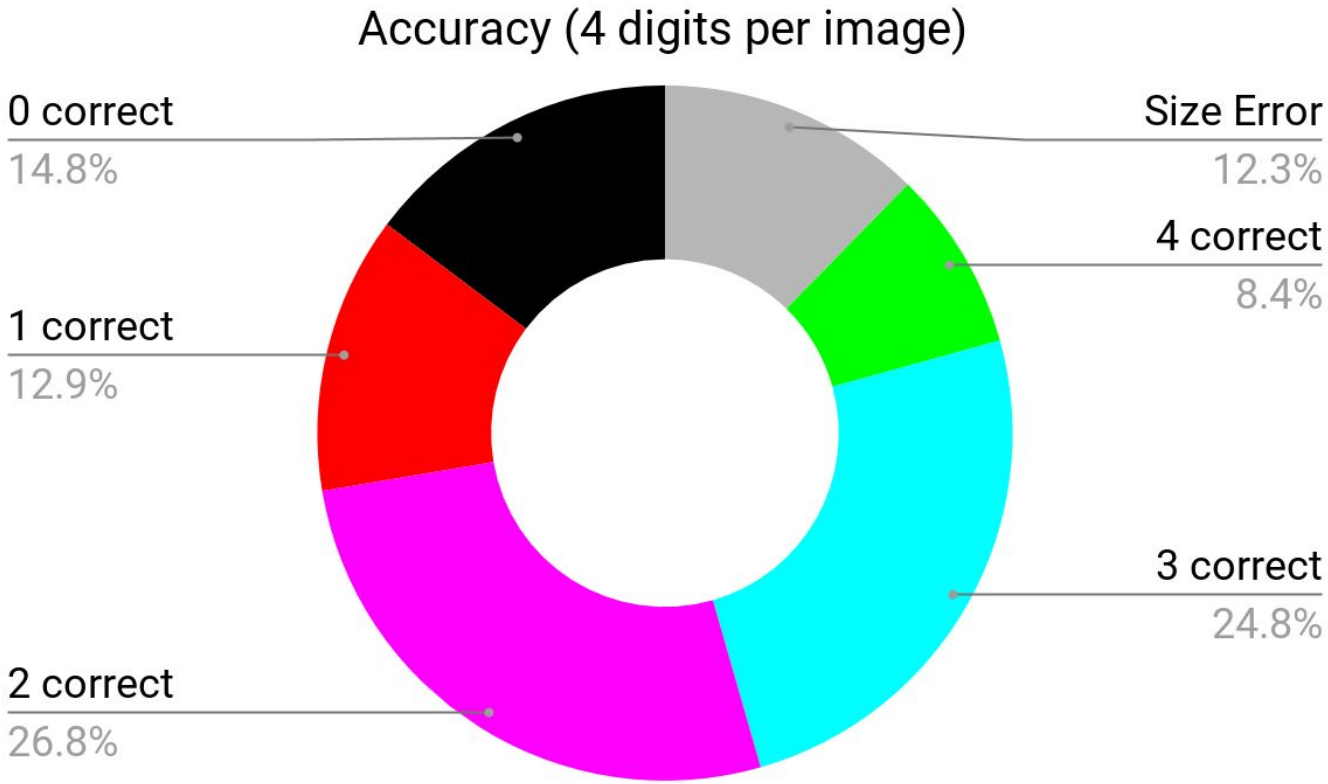
SVM Classifier

17,500 images

Accuracy (on 15,042)

Mean: 0.579

SD: 0.246



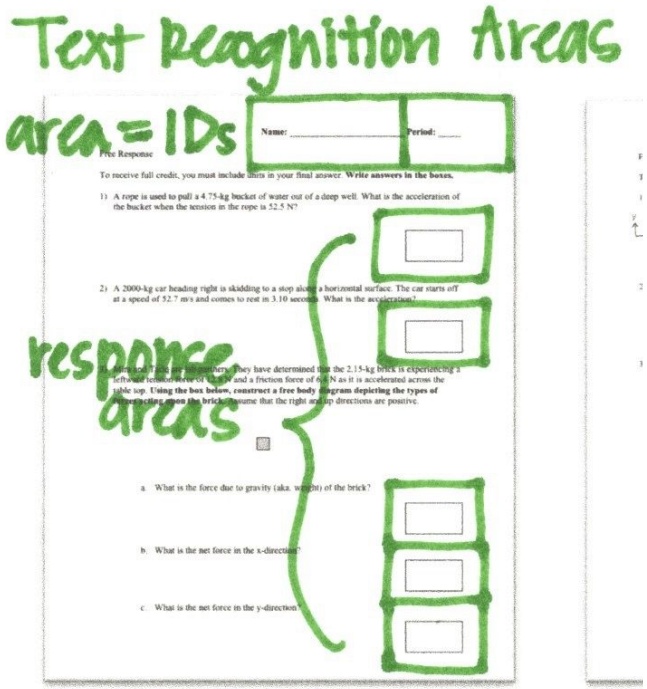
Results

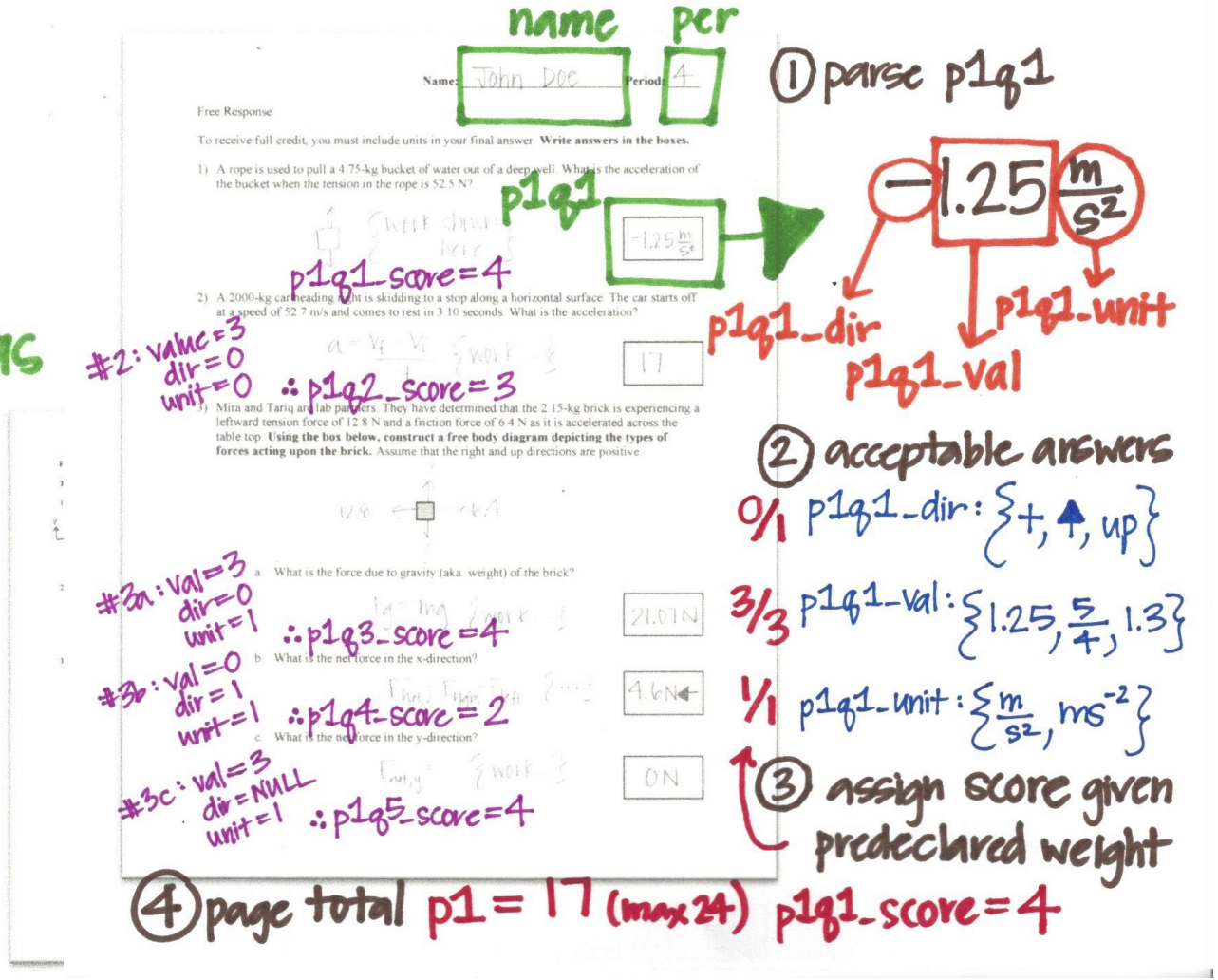
Size Error results needs a deeper look.

	image	truth	predict	correct
	/merge_4_7____3982.png	[3, 9, 8, 2]	[3, None, 2, 8, 2]	False
	/merge_4_8____1551.png	[1, 5, 5, 1]	[1, 2, 2, 8, 8]	False
	nerge_4_17____9373.png	[9, 3, 7, 3]	[8, 3, 2, None, None]	False
	nerge_4_21____0245.png	[0, 2, 4, 5]	[5, 2, 4, None, None, 2]	False
	nerge_4_25____1037.png	[1, 0, 3, 7]	[8, 0, 3, 2, None]	False
	...	...	...	...
	e_4_17477____5949.png	[5, 9, 4, 9]	[5, 8, None, None, 8]	False
	e_4_17479____4067.png	[4, 0, 6, 7]	[4, 0, 6, None, 8]	False
	e_4_17485____5881.png	[5, 8, 8, 1]	[None, 4, 8, 8, 1]	False
	e_4_17488____3085.png	[3, 0, 8, 5]	[3, 0, 8, None, 4]	False
	e_4_17489____3093.png	[3, 0, 9, 3]	[3, 0, 8, None, None]	False

	image	truth	predict	correct	score
17460	____0414.png	[0, 4, 1, 4]	[0, 4, 1, 4]	[True, True, True, True]	1.00
17461	____8443.png	[8, 4, 4, 3]	[8, 4, 4, 3]	[True, True, True, True]	1.00
17463	____2446.png	[2, 4, 4, 6]	[2, 4, 4, 8]	[True, True, True, False]	0.75
17464	____7761.png	[7, 7, 6, 1]	[2, 2, 6, 8]	[False, False, True, False]	0.25
17465	____4866.png	[4, 8, 6, 6]	[4, 8, 6, 8]	[True, True, True, False]	0.75
17466	____1170.png	[1, 1, 7, 0]	[1, 1, 2, 0]	[True, True, False, True]	0.75
17468	____0351.png	[0, 3, 5, 1]	[0, 2, 5, 1]	[True, False, True, True]	0.75
17470	____9106.png	[9, 1, 0, 6]	[3, 8, 0, 0]	[False, False, True, False]	0.25
17473	____6187.png	[6, 1, 8, 7]	[0, 7, 8, 5]	[False, False, True, False]	0.25
17474	____9427.png	[9, 4, 2, 7]	[8, 4, 2, 2]	[False, True, True, False]	0.50
17475	____0976.png	[0, 9, 7, 6]	[0, 8, 2, 8]	[True, False, False, False]	0.25
17476	____3694.png	[3, 6, 9, 4]	[3, 6, 8, 8]	[True, True, False, False]	0.50
17478	____7058.png	[7, 0, 5, 8]	[8, 0, 5, 8]	[False, True, True, True]	0.75
17480	____9618.png	[9, 6, 1, 8]	[8, 6, 1, 8]	[False, True, True, True]	0.75
17481	____9693.png	[9, 6, 9, 3]	[8, 0, 8, 3]	[False, False, False, True]	0.25
17482	____8660.png	[8, 6, 6, 0]	[8, 0, 8, 0]	[True, False, False, True]	0.50
17483	____4302.png	[4, 3, 0, 2]	[8, 3, 0, 2]	[False, True, True, True]	0.75

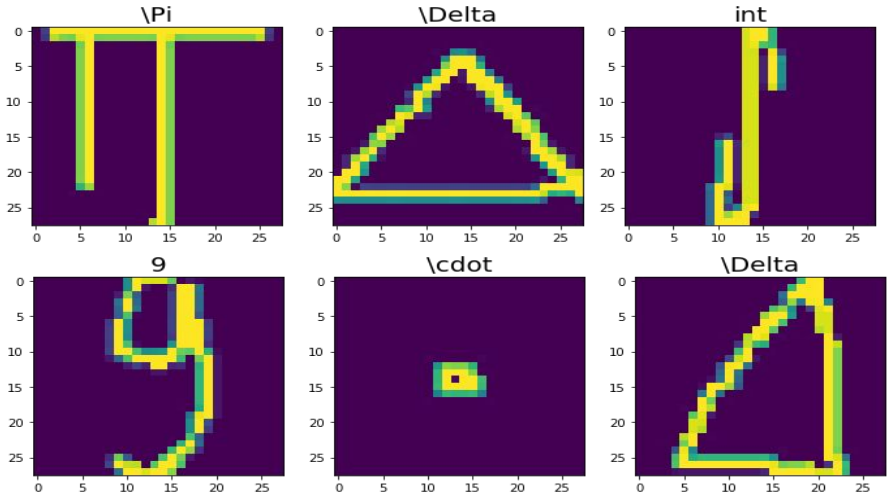
Nitty Gritty

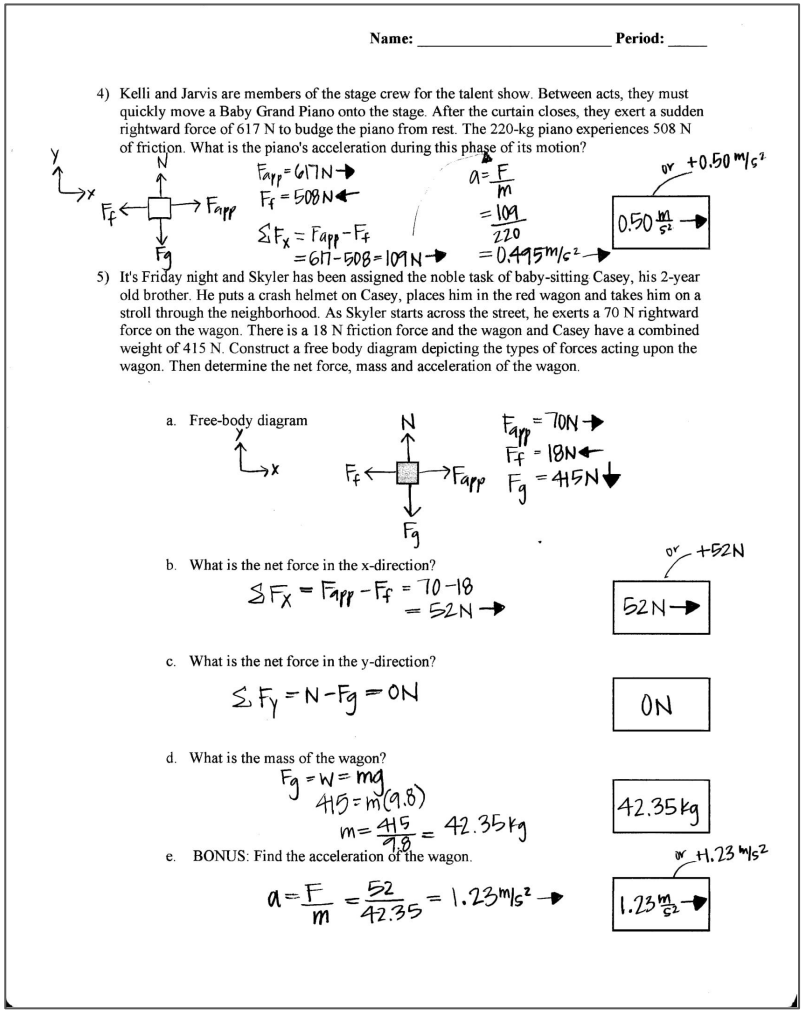




Future Directions

1) Units & direction
2) Organic chemistry
3) OCR + NLP





Name: _____ Period: ____

4) Kelli and Jarvis are members of the stage crew for the talent show. Between acts, they must quickly move a Baby Grand Piano onto the stage. After the curtain closes, they exert a sudden rightward force of 617 N to budge the piano from rest. The 220-kg piano experiences 508 N of friction. What is the piano's acceleration during this phase of its motion?

$F_{app} = 617\,N \rightarrow$, $F_f = 508\,N \leftarrow$

$\Sigma F_x = F_{app} - F_f = 617 - 508 = 109\,N \rightarrow$

$a = \frac{F}{m} = \frac{109}{220} = 0.495\,m/s^2 \rightarrow$ or $+0.50\,m/s^2$

$0.50\,\frac{m}{s^2} \rightarrow$

5) It's Friday night and Skyler has been assigned the noble task of baby-sitting Casey, his 2-year old brother. He puts a crash helmet on Casey, places him in the red wagon and takes him on a stroll through the neighborhood. As Skyler starts across the street, he exerts a 70 N rightward force on the wagon. There is a 18 N friction force and the wagon and Casey have a combined weight of 415 N. Construct a free body diagram depicting the types of forces acting upon the wagon. Then determine the net force, mass and acceleration of the wagon.

a. Free-body diagram

$F_{app} = 70\,N \rightarrow$, $F_f = 18\,N \leftarrow$, $F_g = 415\,N \downarrow$

b. What is the net force in the x-direction?

$\Sigma F_x = F_{app} - F_f = 70 - 18 = 52\,N \rightarrow$

$52\,N \rightarrow$ or $+52\,N$

c. What is the net force in the y-direction?

$\Sigma F_y = N - F_g = 0\,N$

$0\,N$

d. What is the mass of the wagon?

$F_g = w = mg$

$415 = m(9.8)$

$m = \frac{415}{9.8} = 42.35\,kg$

$42.35\,kg$

e. BONUS: Find the acceleration of the wagon.

$a = \frac{F}{m} = \frac{52}{42.35} = 1.23\,m/s^2 \rightarrow$

$1.23\,\frac{m}{s^2} \rightarrow$ or $+1.23\,m/s^2$