

Project Goal

CNN to solve Sudoku puzzles

Summary

As a part of a team project, I created a training data set for our convolutional neural network, CNN, model. The model input is an image of an unsolved Sudoku puzzle, the model extracts the cells with prefilled numbers, predicts the numbers present, and based on the predictions solves the Sudoku puzzle.

I created 37,800 labeled images with printed digits with 4,200 images of each digit 1-9. The training data set has 60 different fonts and was created using InDesign and Python. The original 540 images were exported in order to maintain the order of the images in the file directory. With this predictability, the corresponding labels were added to a numpy file in Python.

The original 'clean' images were then transformed 70 times using numpy transformations and overlaying images using openCV in Python. The additional corresponding labels were created alongside the transformations. The final training data set had printed numbers with borders and noise to more accurately reflect the numbers extracted from the Sudoku puzzles.

Included

Images of process and model results

	2		3	8	1			
		8			6			1
		3				6	8	
2				4			7	6
1			9	6	2			5
9	3			7				2
	6	2				1		
3			6			5		
			4	1	8		6	

Scan and interpret Sudoku puzzle by cell

	2		3	8	1			
		8			6			1
		3				6	8	
2				4			7	6
1			9	6	2			5
9	3			7				2
	6	2				1		
3			6			5		
			4	1	8		6	

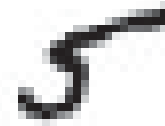
Predict numbers present in Sudoku puzzle using CNN

6	2	9	3	8	1	7	5	4
4	5	8	7	9	6	3	2	1
7	1	3	2	5	4	6	8	9
2	8	5	1	4	3	9	7	6
1	7	4	9	6	2	8	3	5
9	3	6	8	7	5	4	1	2
8	6	2	5	3	9	1	4	7
3	4	1	6	2	7	5	9	8
5	9	7	4	1	8	2	6	3

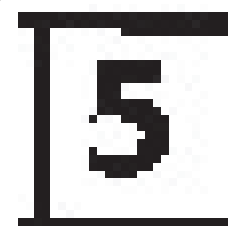
Sudoku puzzle solved and results displayed



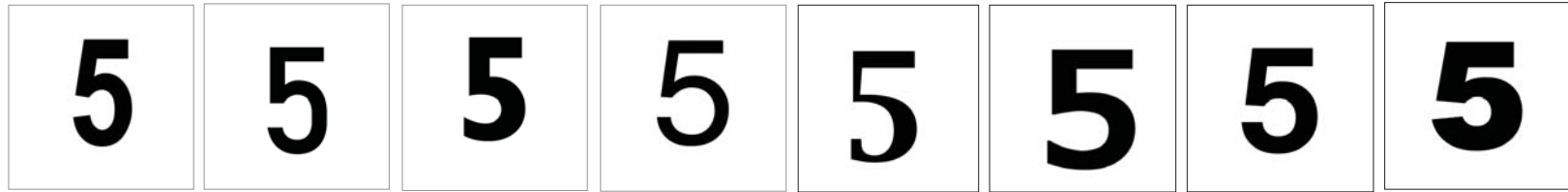
Extract numbers from puzzle and use training data sets in CNN to predict numbers present



Handwritten MNIST data set



New printed digits data set



Considerations:
Image and digit proportions, font weights

60 different fonts per 1-9 digit
540 images total



Considerations:
Maintain digit visibility within image frame

Overlay 40 different borders

Skew and shift 30 times
70 transformations per original image



Considerations:
Space between 'noise' and digits

Examples of new printed digits data set
37,800 total images

Results

With the printed digits training data set, we achieved 96.2% accuracy rather than 23.1% accuracy with the well known handwritten MNIST data set. Note the use of a convolutional neural network was a project requirement. OCR, optical character recognition, is a potentially a more reliable approach within our Sudoku project than the CNN model.