TexNet: From Handwriting to LaTeX

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PREDICTING

We wanted to create a pipeline that automates the repetitive, tedious process of writing up math equations into LaTeX. Our project implements the first stage of this task: character segmentation and classification using a CNN we implemented in Keras. We feed in an image of a handwritten equation and output the characters present along with their corresponding bounding box information, which we plan to later use in constructing the equivalent LaTeX expression.

DATA

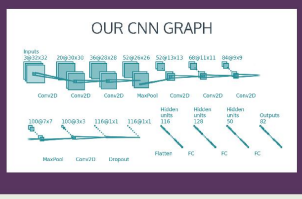
We trained our model using Xai Nano's Handwritten Math Symbols Dataset found on Kaggle, which has examples for 82 classes (numbers, symbols, Greek letters, etc.), which we perform image binarization on. We used 147,234 train and 37,161 test examples.

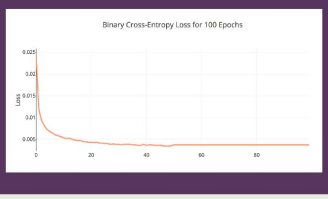
FEATURES

Our input data is simply the pixels of a binarized image, so we hypothesize that the model learns features including curvature, boundary noise, stroke count, distance, and length in deeper layers.

MODEL

Initially, we tried to implement YOLO for this task. However, that was a bad idea. We then switched to implementing a character segmentation class and building our own CNN.

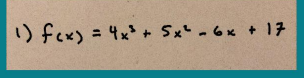




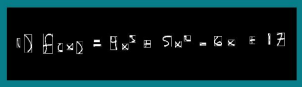
RESULTS

YOLOv2-Tiny	Loss around 0.31 after 40k steps Inaccurate predictions and low confidence
Custom CNN	Batch size: 64, Epochs: 100, Learning Rate: 0.001 Loss: 0.0043,Train Accuracy: 0.99, Test Accuracy: 0.99

Real-World Input Image



PREPROCESS + SEGMENT + CLASSIFY



Prediction: ['1', ')', 'f', '(', 'x', ')', '=', '4', 'x', 'y', '+', '5', 'x', 'i', '−', '6', 'x', '+', 'ascii_124', '7']

DISCUSSION

We found that separating the segmentation and classification tasks is a much better approach for handwritten character recognition than YOLO. We achieved reasonably good results, as our pipeline can successfully segment characters from an image and predict the correct class with good accuracy for non-ambiguous symbols. The model confuses ambiguous pairs like '1' and 'ascii_124' = |; however that can also be confusing for humans. It also has difficulty with superscripts. Overall, we feel that this was a successful start towards a complete handwriting to LaTeX conversion pipeline.

FUTURE

We plan on continuing this project over the coming months to complete the pipeline by building an RNN that can take the structured data we obtain from our segmentation/ classification step and output the corresponding LaTeX expression.

RESOURCES & RELATED WORK

[1] J. Redmond and A. Farhadi, "YOLOv3: An Incremental Improvement," 08-Apr-2018.
[2] X. Xiao, L. Jin, Y. Yang, W. Yang, J. Sun, and T. Chang, "Building Fast and Compact Convolutional Neural Networks for Offline Handwritten Chinese Character Recognition," 26-Feb-2017.
[3] X. Yang and J. Pu, "MDig: Multi-digit Recognition using Convolutional Neural Network on Mobile," 08-Jun-2015.
[4] X. Chen, "Convolution Neural Networks for Chinese Handwriting Recognition," 2016.
[5] L. Yan, "Recognizing Handwritten Characters," 2016.