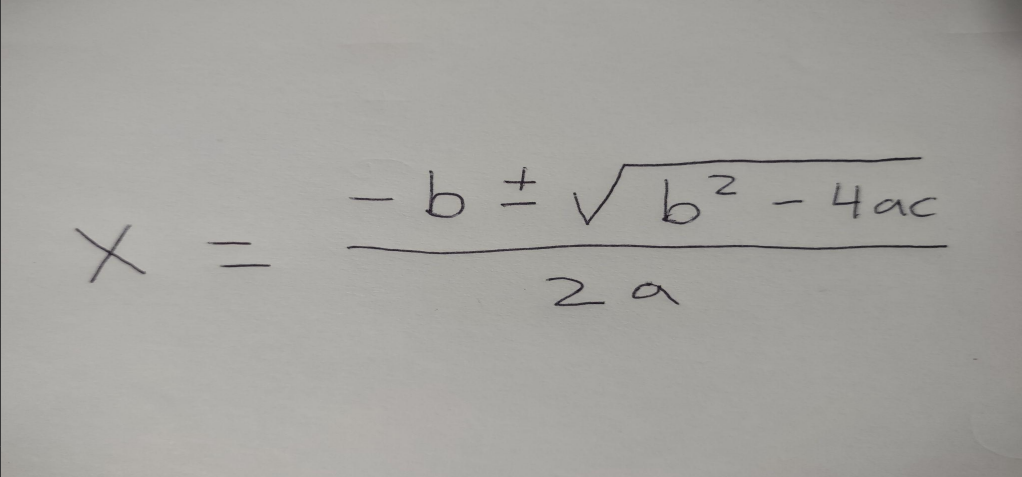


The background is dark grey with a fine white speckle pattern. Scattered around the central text are various colorful icons: a large orange jagged line in the top left, a blue triangle in the top center, a blue star in the top right, a green number '3' on the left, a yellow number '2' on the right, a yellow pencil in the bottom left, a white eraser in the bottom left, a blue plus sign in the bottom center, a green pencil in the bottom right, and an orange percent sign in the bottom right. There are also several small white dots.


Handwritten Equation Solver

Image Parsing and Symbol
Identification



A photograph of a piece of white paper with the quadratic formula written in black ink. The formula is $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$. To the left of the paper is a dashed orange line. To the right is a green arrow pointing towards the paper and a small white dot.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$



A white arrow pointing downwards from the handwritten formula to the typed formula.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Two Separate Problems

4 5 6 7 8 9 10

Step 1

7 5 9 4 6 8

Step 2

7 5 9 6 4 8

Image Parsing

- OpenCV
- Find Contours
- Identify changes in contrast
- Draw bounding Boxes based on contours

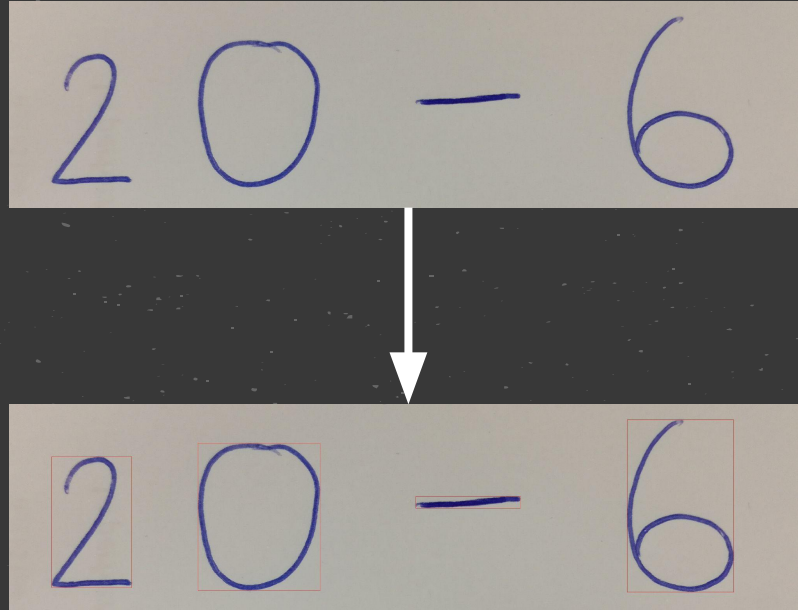
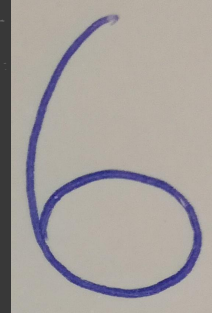
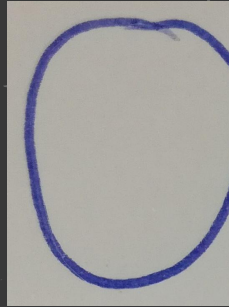
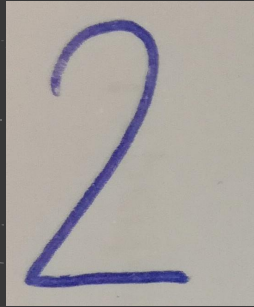


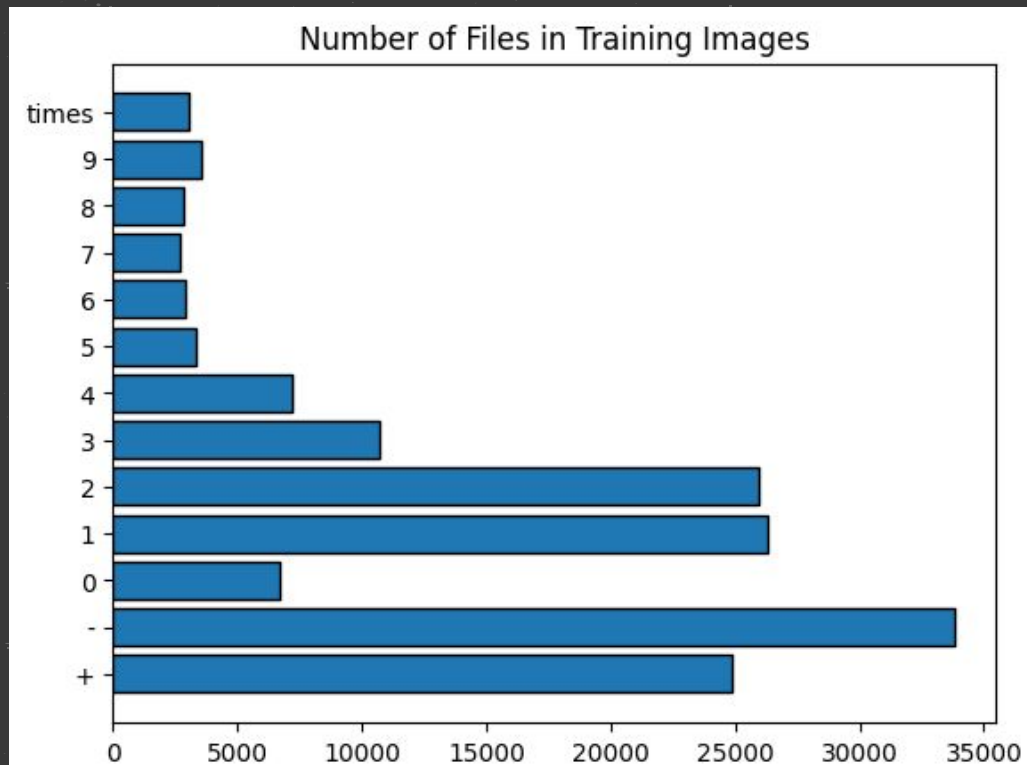
Image Cropping

- Crop Images based on bounding box coordinates
- Left to right in order to read equation

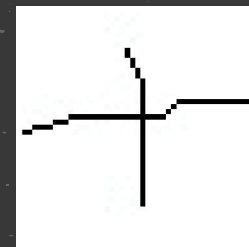
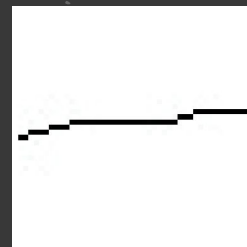
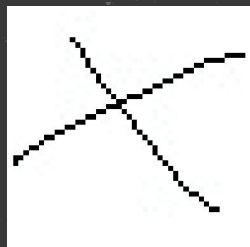
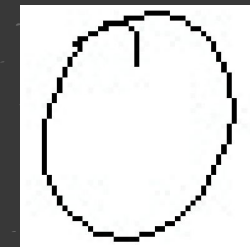
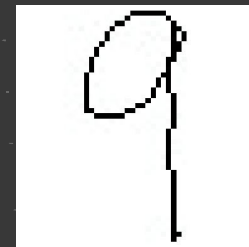
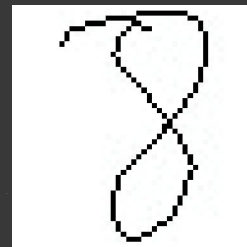
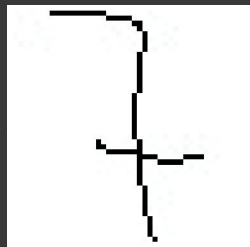
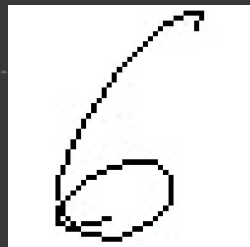
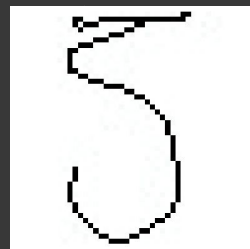
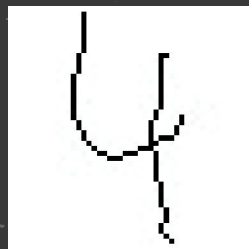
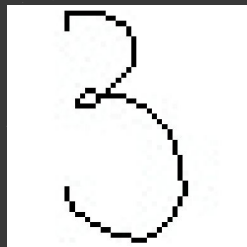
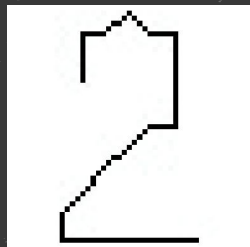
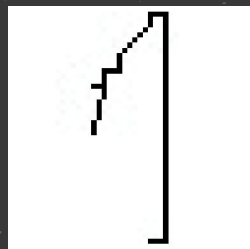


Mathematical Symbol Dataset

- Over 200k mathematical symbols
- Division symbol varied from slash to obelus
- Different numbers of each
- Some symbols were hard to classify

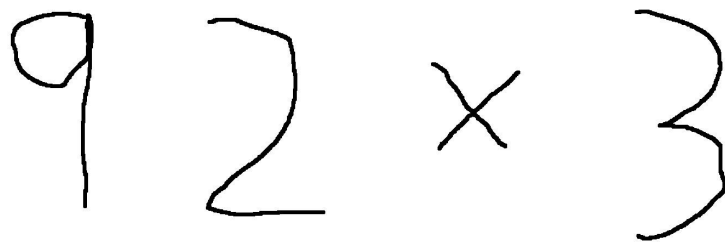


Symbol Examples



Test Set Creation

- Couldn't find dataset of handwritten equations
- Created test set manually
- Used Paint or similar drawing apps

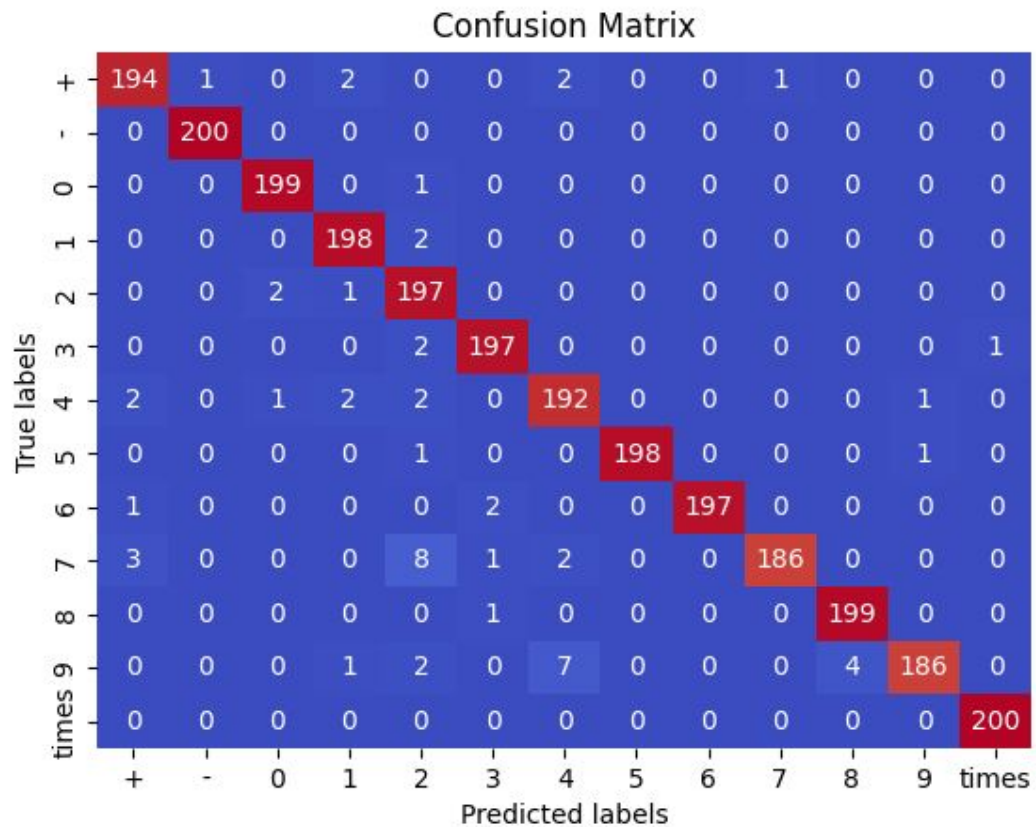
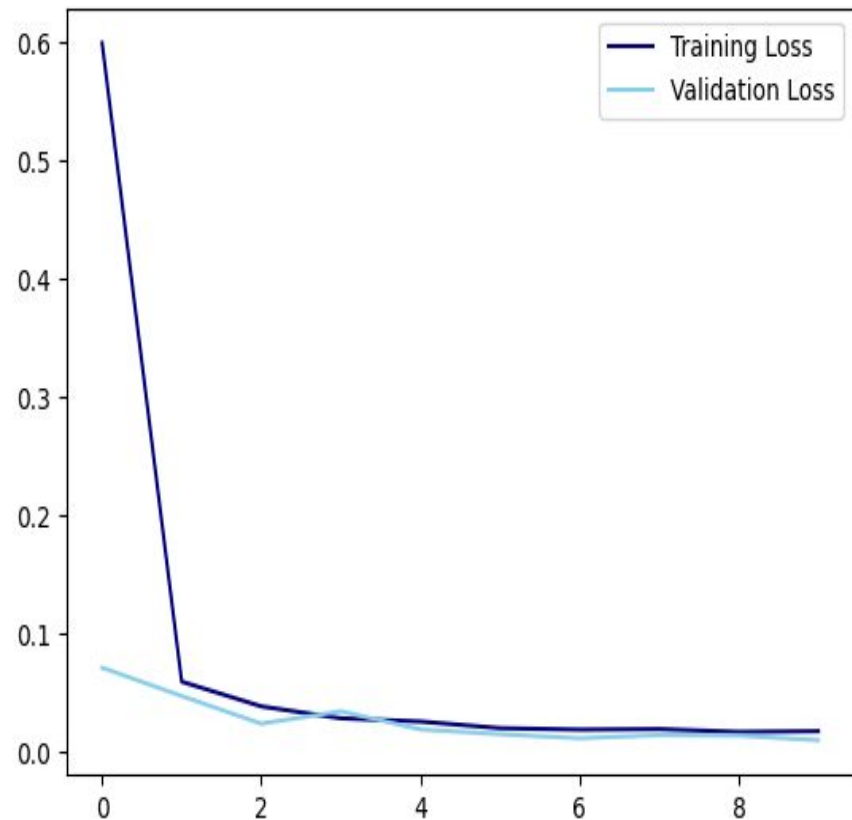


A handwritten equation "92 x 3" is shown inside a white rectangular box. The numbers and the multiplication symbol are drawn in a simple, hand-drawn style with black ink.

Model Training

Hidden Layers	Nodes Per Layer	Max Pooling	Dropout	Validation Accuracy	Test Accuracy
2	32	Yes	No	0.972	0.62
3	64	Yes	Yes	0.966	0.78
3	32	No	No	0.973	0.76
3	64	Yes	No	0.965	0.82
3	64	Yes	Yes	0.978	0.84

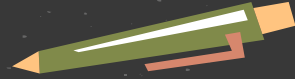
Final Model



Demonstration!



Thank You for Listening
And
Congratulations Everyone!



Questions?