



Computer Move Suggestions from Physical Game Images

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Introduction

- AI can outperform most humans in many games
- Computer analysis programs for board games requires a digital version of the board
- We aim to digitalize Set and Scrabble game states
- Our contributions:
 - Create synthetic datasets for Set and Scrabble
 - Use traditional computer vision technique to get individual game piece images from an image of the entire board
 - CNN to output a predicted game piece type
- Input: Image of entire game board
- Output: Reconstructed digital board
- Our method achieved 95.58% accuracy on Set and 93.10% accuracy on Scrabble.

Dataset + Features

- Created dataset of entire boards in Blender
- Detected individual grids using traditional CV to create dataset of game pieces

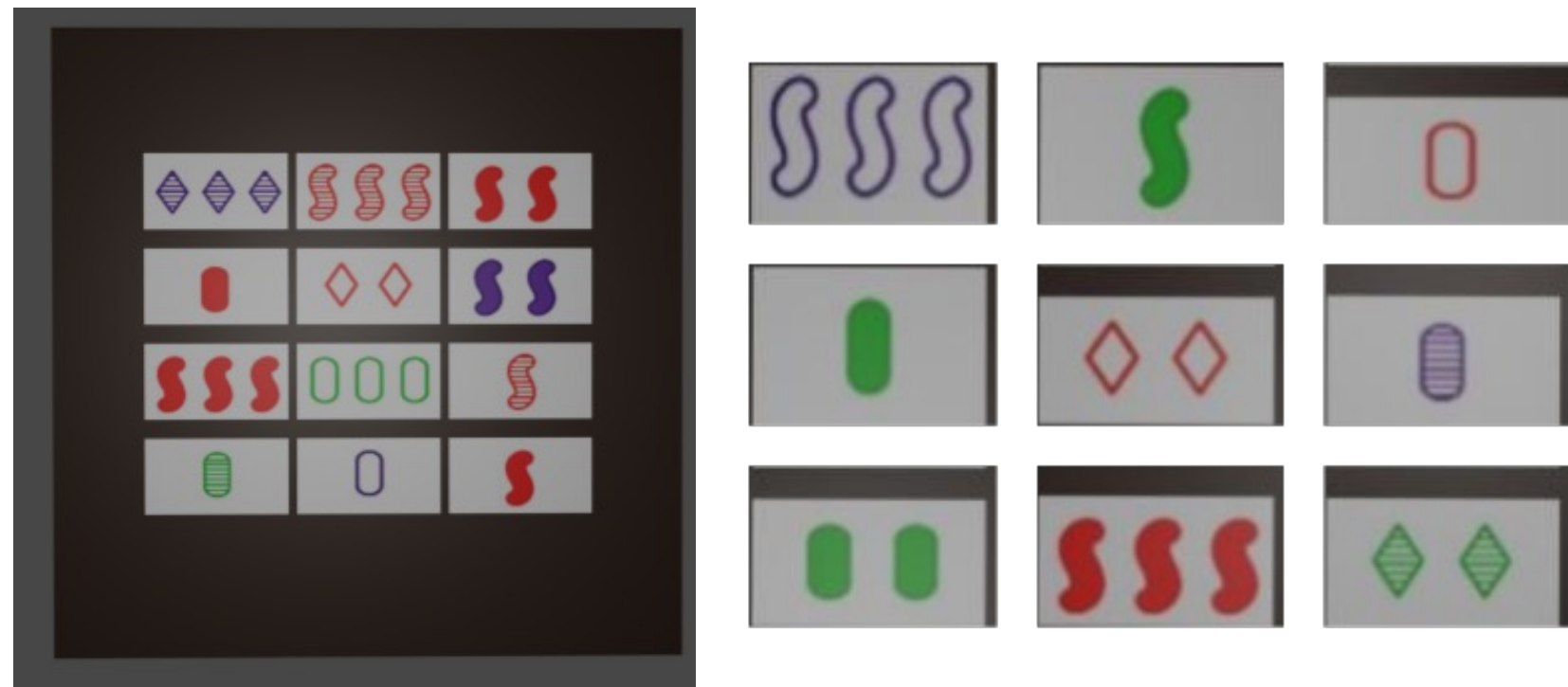


Figure 1: Set Game Layout and Cards



Figure 2: Scrabble Game Board and Pieces

Methods

- Game board is processed as seen in Figure 3 to identify and crop individual grids
- During training, each grid image trains the CNN
- During testing, each grid image yields a prediction on the piece on the grid

Game Board Detection

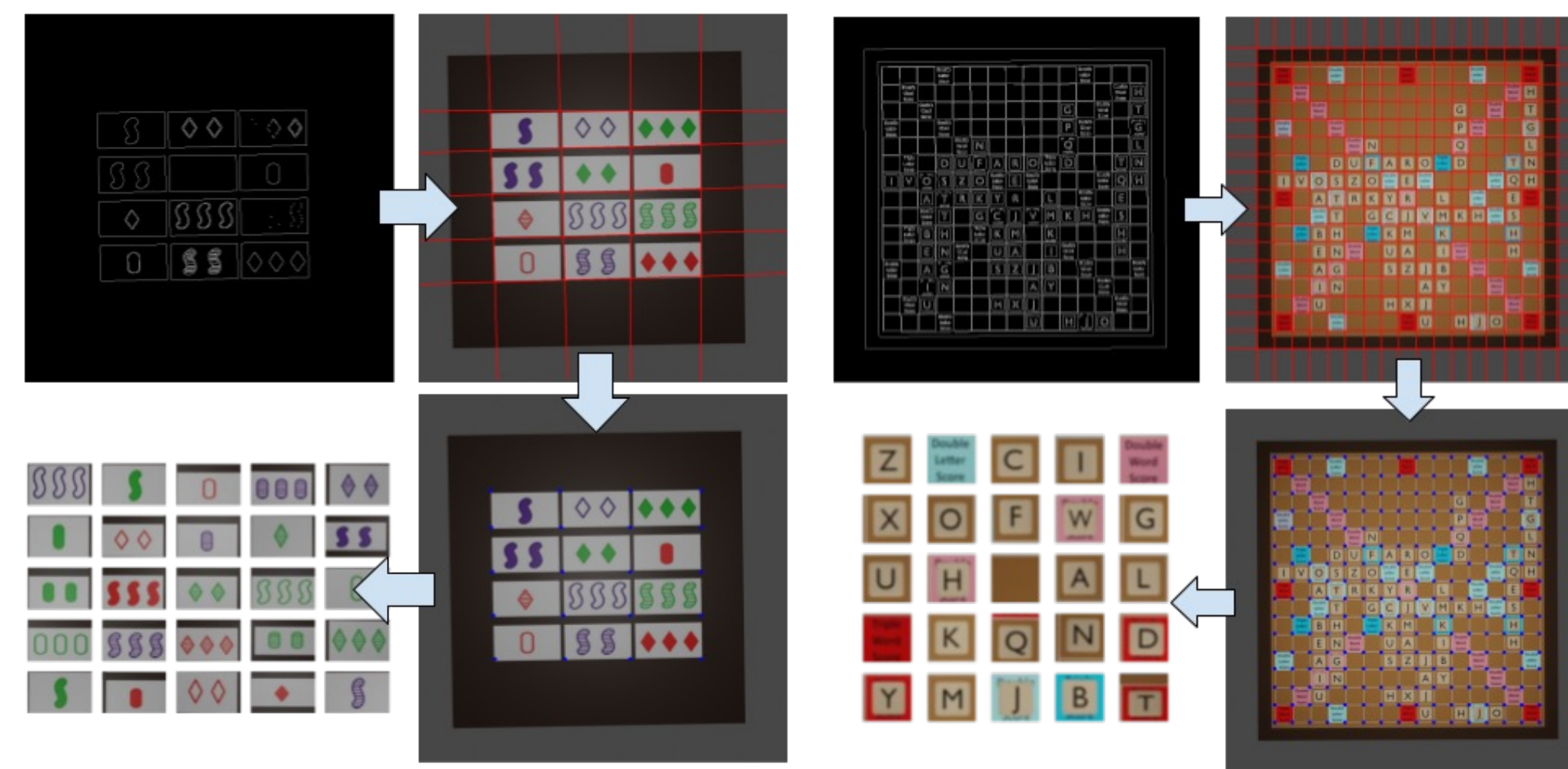


Figure 3: Canny edge detection, Hough lines transform, and point cluster applied on board images to detect and crop game pieces

Game Piece Recognition

- Input: Image of Game Piece
- Output: Prediction Class
- 4 CNNs used for Set for each property

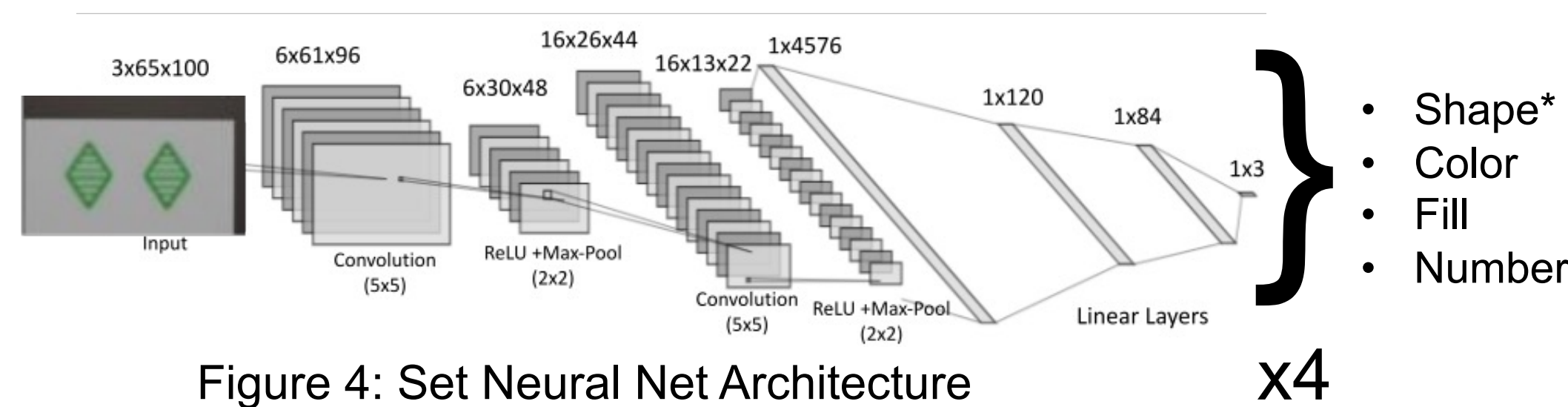


Figure 4: Set Neural Net Architecture

*Shape: Diamond, Oval, Squiggle; Color: Red, Green, Purple; Fill: Empty, Stripe, Solid; Number: 1, 2, 3

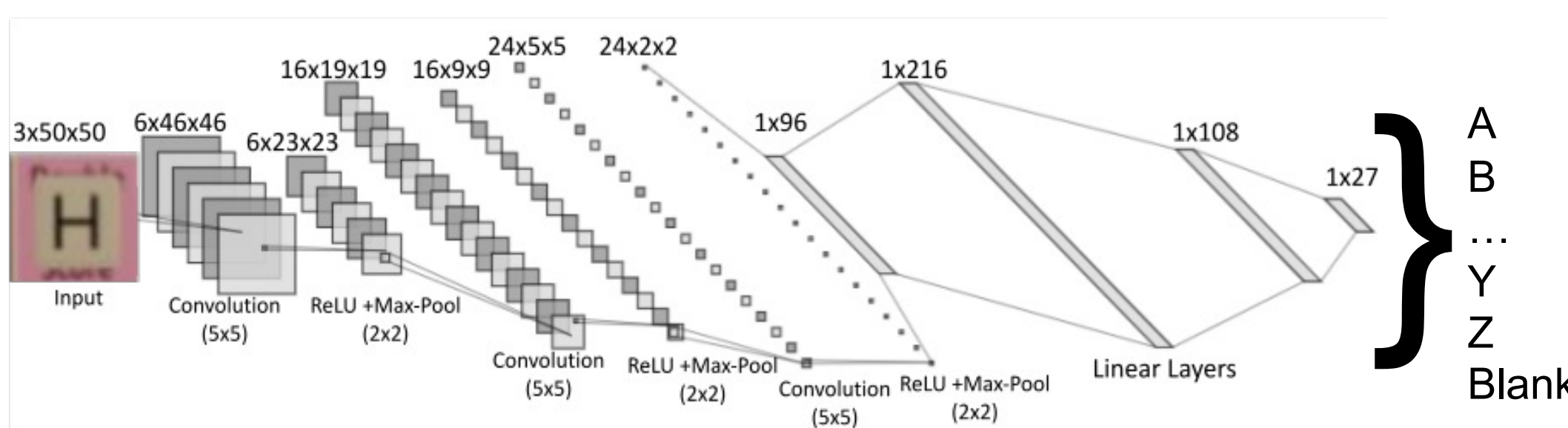


Figure 5: Scrabble Neural Net Architecture

Results

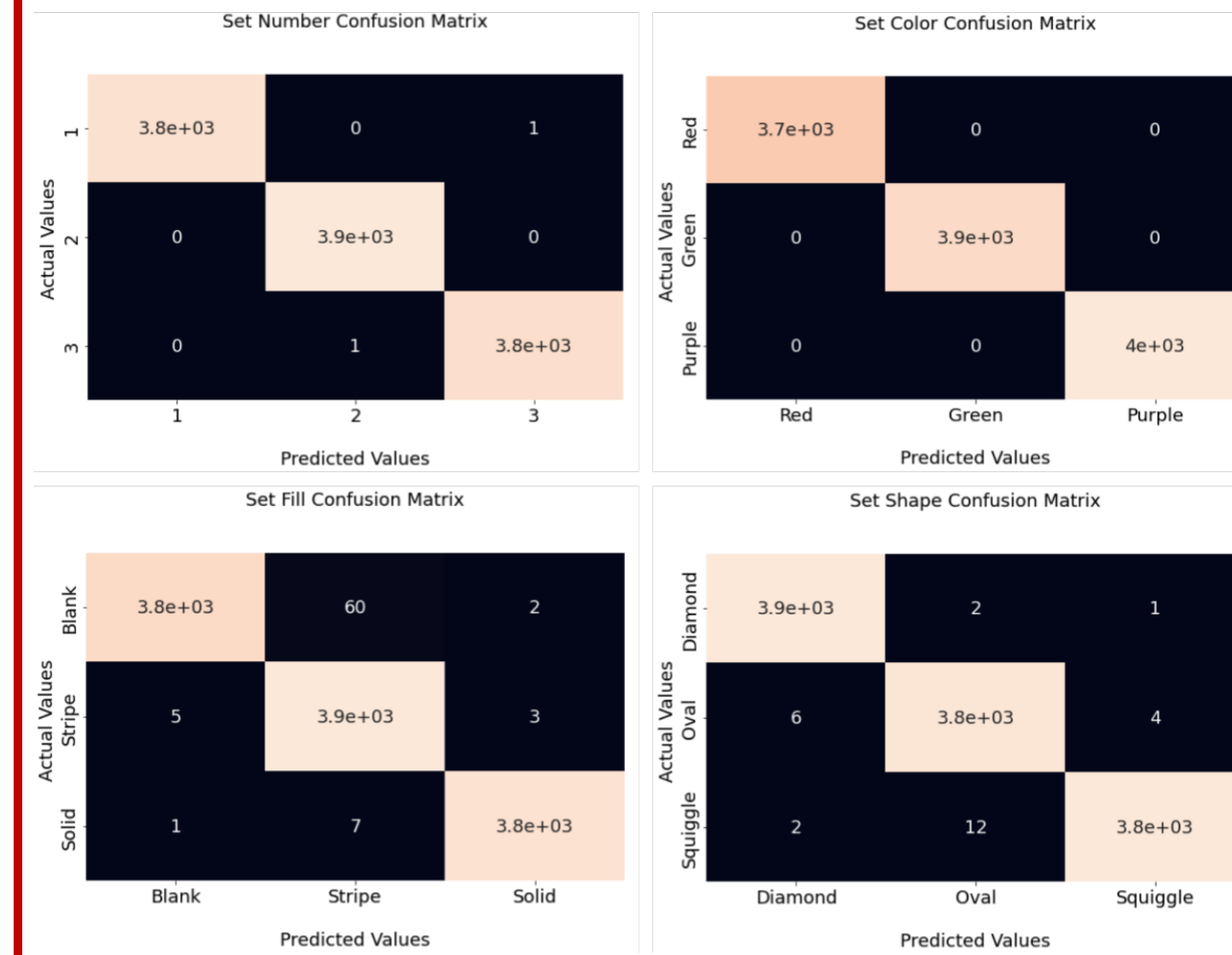


Figure 6: Set Cards Confusion Matrix

PROPERTY	ACC	F1
SHAPE	99.76	99.75
COLOR	100.00	100.00
FILL	99.32	99.83
NUMBER	99.98	99.97

Table 1: Set CNN Accuracies and F1 Score Across Properties

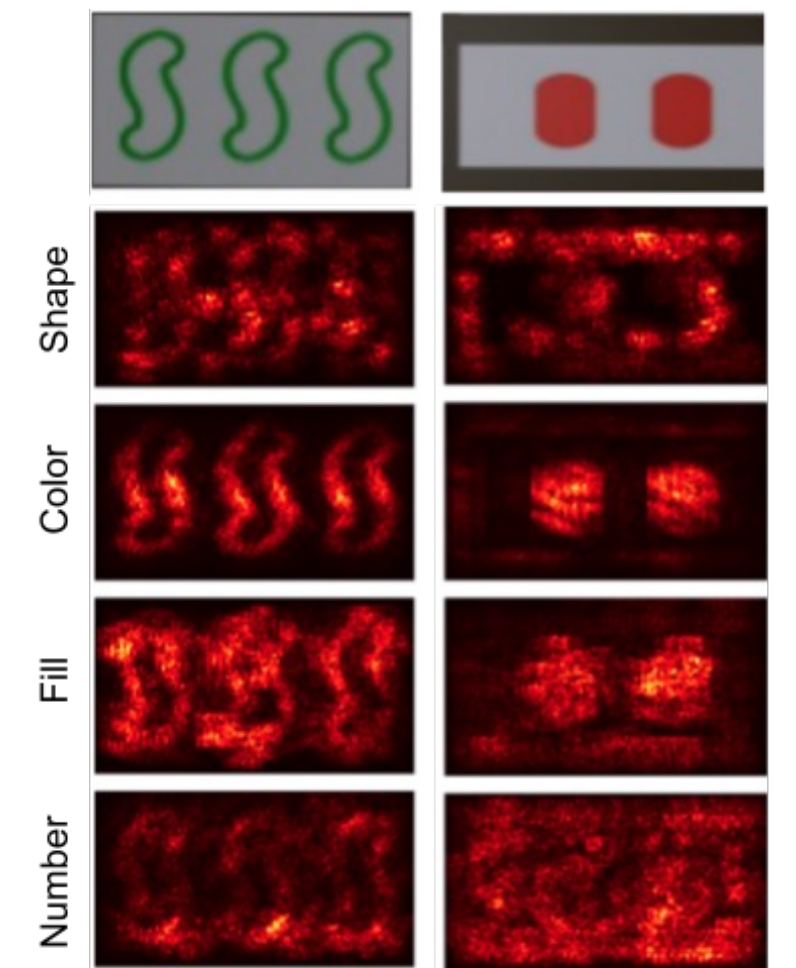


Figure 7: Set Cards Saliency Maps

LETTER	ACC	F1
A-Z AVG	98.67	97.30
BLANK	99.44	99.38
OVERALL	98.70	97.38

Table 2: Scrabble CNN Accuracies and F1 Score Across Properties

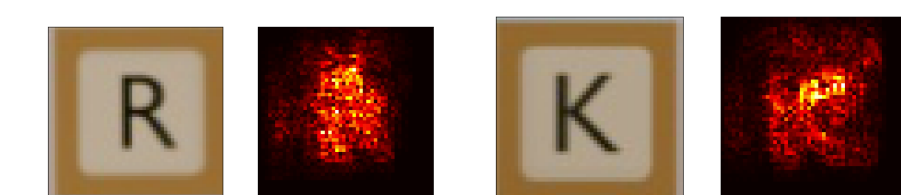


Figure 9: Scrabble Tiles Saliency Maps

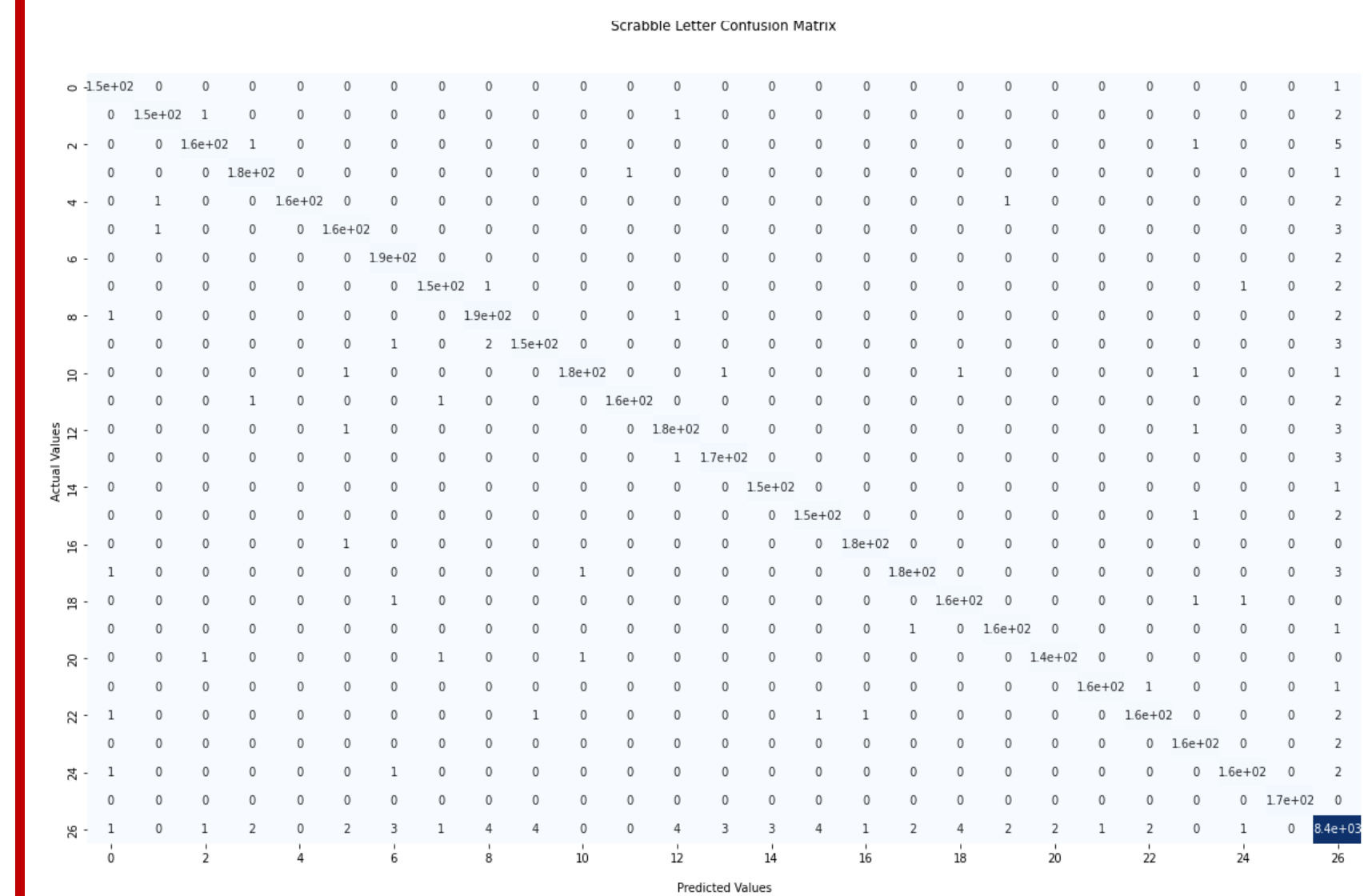


Figure 8: Scrabble Tiles Confusion Matrix

Conclusion

- CNN classification was extremely accurate (quantitatively and qualitatively)
- Most errors come from the cropping as ideal lighting conditions are necessary for this task
- Synthetic datasets generated enough good quality data for our model to perform well
- Our results indicate that as segmentation techniques improve, other board games (including those without standard grid layouts) can also be scanned and digitalized
- In the future, we aim to explore more advanced methods of board state detection (heat maps, image segmentation via neural networks, bounding box)