Scrabble Assistant

David Koeplinger
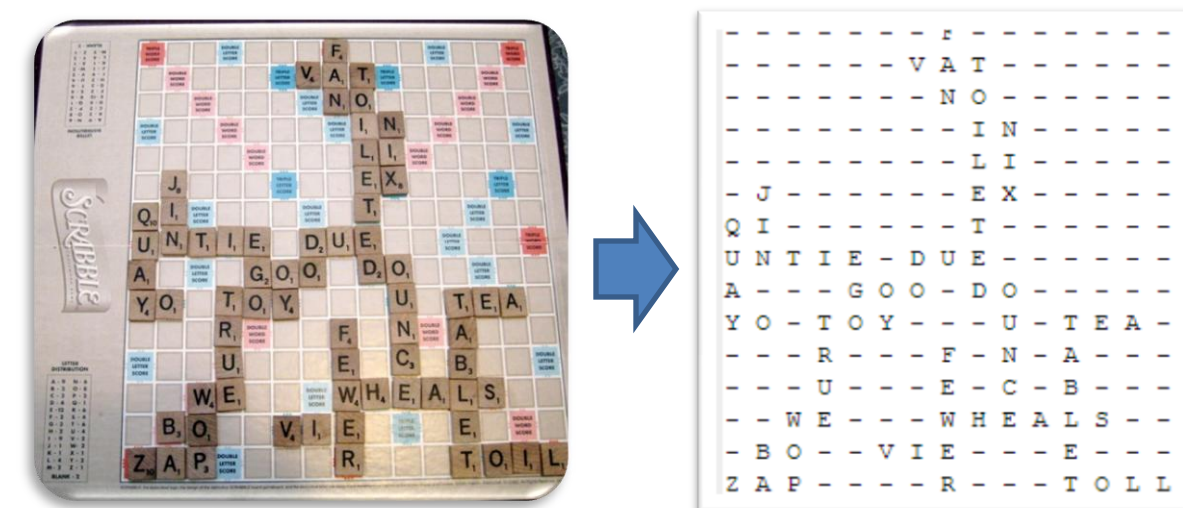### Department of Electrical Engineering, Stanford University

Motivation

Scrabble (noun): a commonly played word game in which players take turns forming words using a set of seven letter tiles and placing them onto a grid, following placement rules similar to a crossword puzzle.
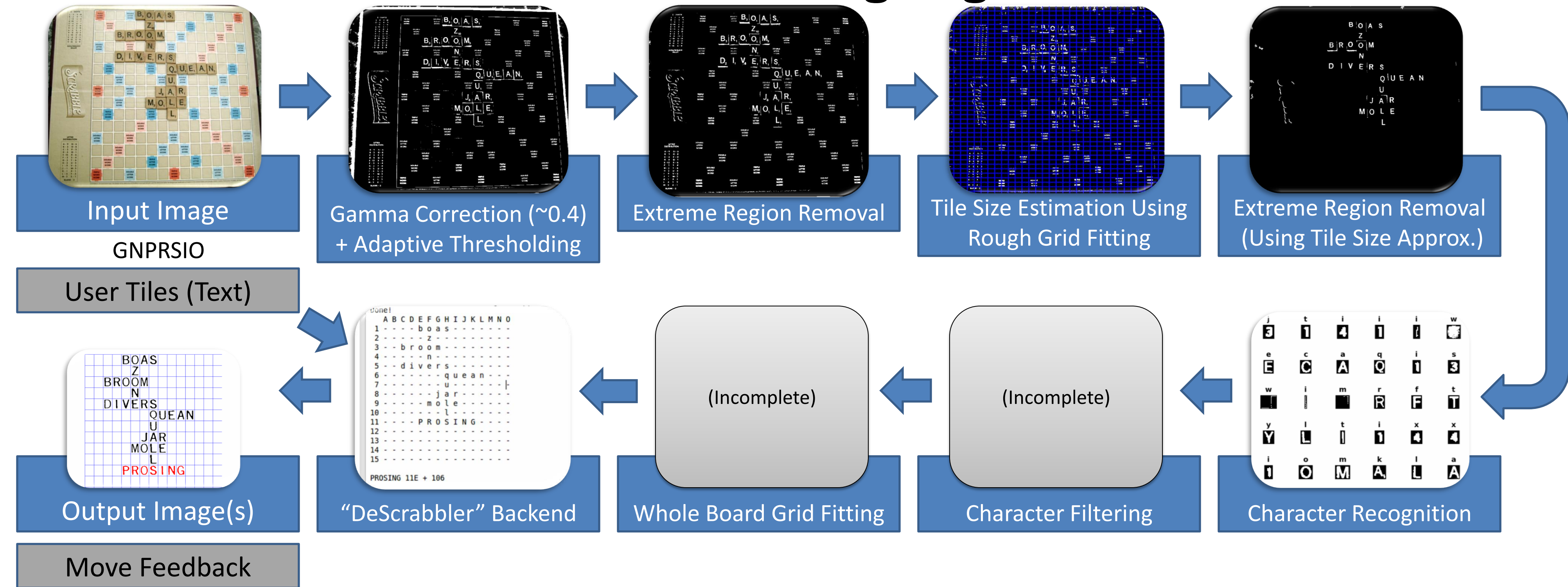
Various tools exist to help players form their tiles into words in Scrabble, but there are very few options when it comes to finding a place to put them on the board. Entering the board into an application is a hassle.

The goal of this project is to create an image processing algorithm which reliably converts a complete image of a Scrabble board to a matrix of characters, which can be used as a frontend for applications like:
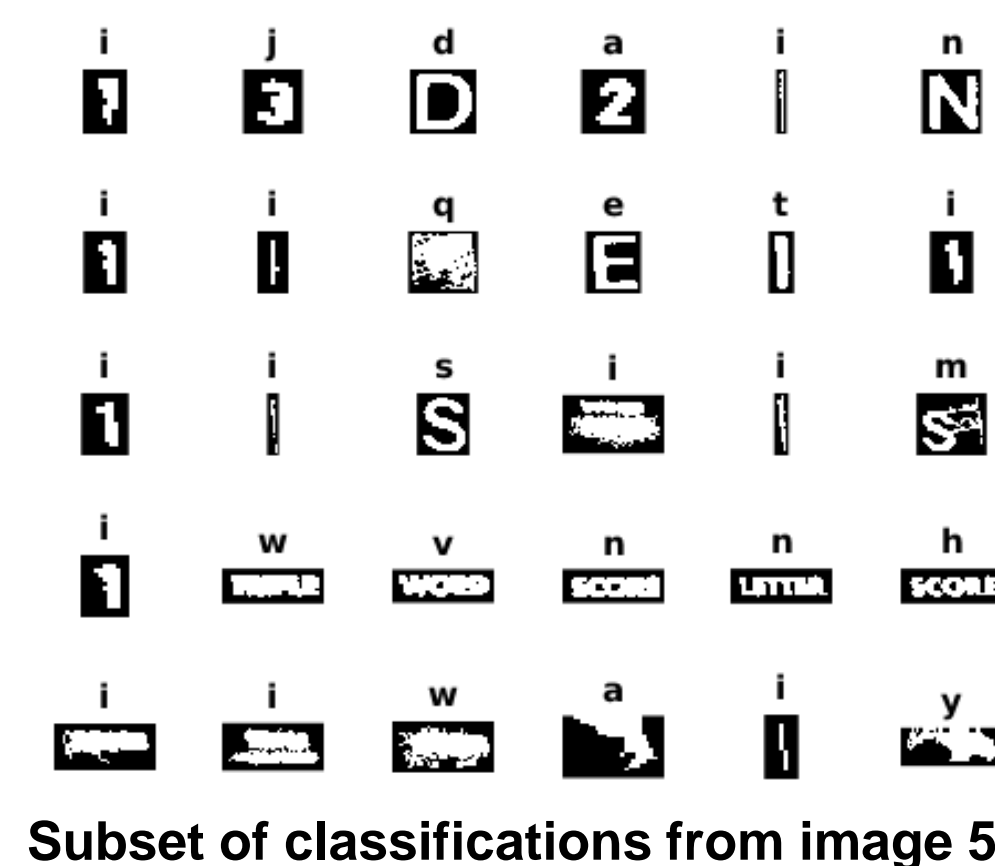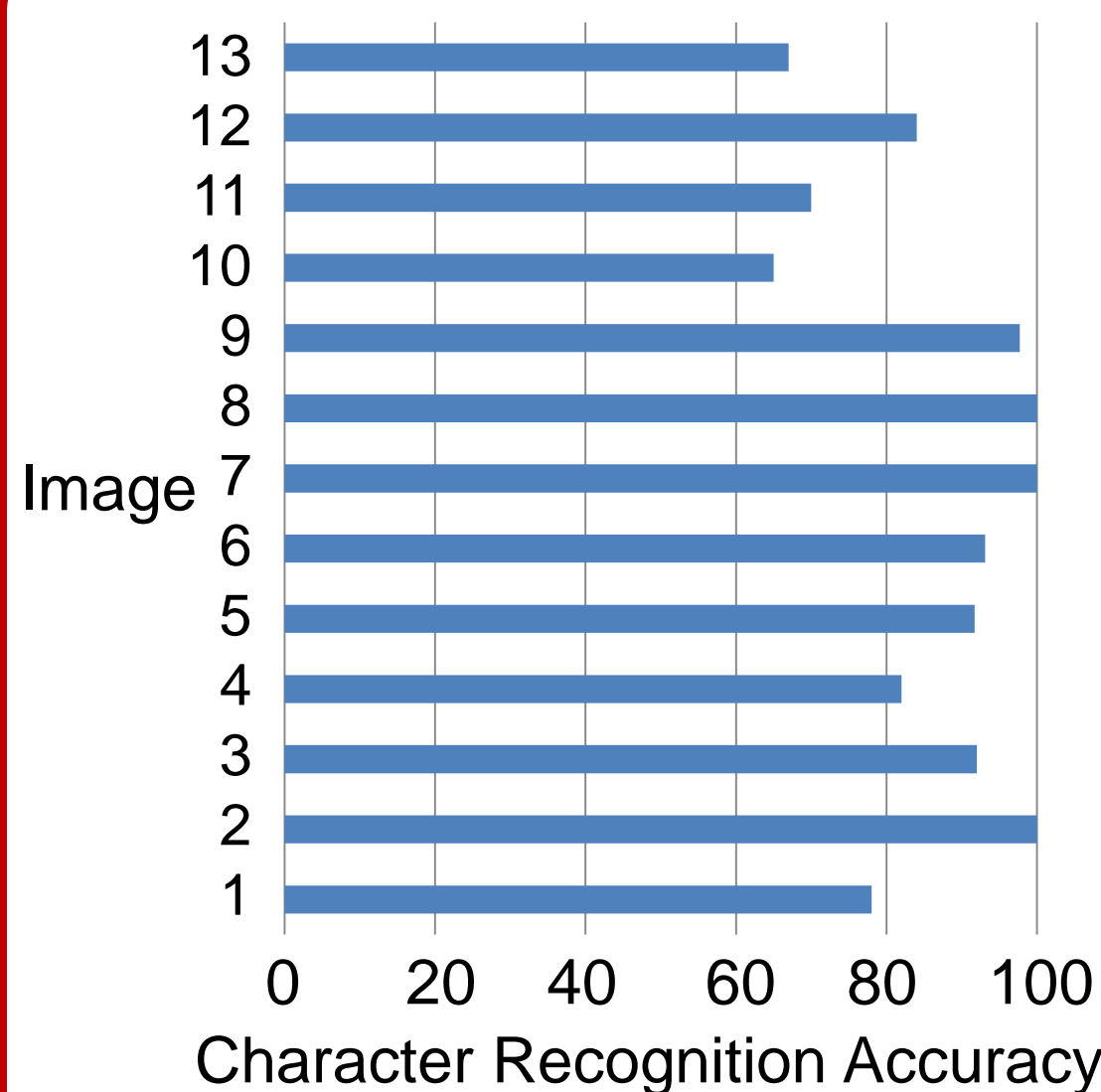• Automated Scrabble "refereeing"
• Automated scoring
• Word placement suggestions, hints
• "Live" Scrabble AI players
• Vocabulary building tools
• Cheating!

Board Processing Algorithm

Input Image → Gamma Correction (~0.4) + Adaptive Thresholding → Extreme Region Removal → Tile Size Estimation Using Rough Grid Fitting → Extreme Region Removal (Using Tile Size Approx.)

User Tiles (Text): GNPRSIO

→ Character Recognition → Character Filtering → (Incomplete) → (Incomplete) → Whole Board Grid Fitting → "DeScrabbler" Backend → Output Image(s)

Move Feedback

Experimental Results

Character Recognition Accuracy (bar chart, Image 1–13)

Subset of classifications from image 5

Several methods for character recognition were considered for recognizing characters in individual tiles. These included:
• Geometric feature extraction [1]
• Hu moment calculation [2] [3]
• Template matching using a reference set of tiles

By far the best recognition rate was achieved using template matching. However, the extraneous region removal step does not remove all. It also does not account for blended regions or characters incorrectly thresholded areas well (see the S misclassified as an M in the figure on the left, for example).

The accuracies given above are for the template matching filter. Character recognition accuracies are calculated as the number of incorrectly labeled characters divided by the total number of characters (letter tiles) in the image. Note that this ignores extraneous regions. The most misclassified pairs are given on the right (actual character in left column).

Orig.	Class.
T	I
I	T
E	F
O	C
D	O

Common Misclassifications

Img	Best Player	Pts	Best Word	Pts
1	UNITIES	73	INQUIET	74
2	SNARKIER	78	INSANER	83
3	REALISM	79	REALISM	79
4	OBLONGS	74	ENGLOBES	76
5	ICEBOAT	73	ICEBOAT	73
6	TURTLERS	71	ULSTER	74
7	TAWNIER	81	WANIEST	86

The 13 images used in these experiments were taken from a series of Scrabble "sweepstakes" blog posts (OneSorryBlog.wordpress.com) Of the 13 rounds, the "Descrabbler" backend (without image processing) beat the highest scoring human in 6, and tied for first in the remaining 7.

Future Work

• Add filter to remove regions which do not closely match any character
    • Binary filter determining if a region is a character or not
    • Or an improved version of the current template matching filter
• Improve grid filtering for tile size estimation
• Add perspective skew correction
• Add processing for tile rack

References

[1] Gaurav, D. D. and Ramesh, R. (2012). *A feature extraction technique based on character geometry for character recognition.* CoRR, vol. abs/1202.3884.

[2] Hu, M. (1962). *Visual pattern recognition by moment invariants.* IRE Trans. Information Theory, vol. 8, no. 2, 179 - 187.

[3] Leung S., Perkins, S., and Rhoades, C. *Bananagrams Tile Extraction and Letter Recognition for Rapid Word Suggestion.* EE368 Winter 2013-2014

[4] Ohya, J., Shio, A., and Akamatsu, S. (1992). *Recognizing characters in scene images.* IEEE Transactions on Pattern Analysis and Machine Intelligence, 214-220.