Moonboard Climbs Difficulty Classification

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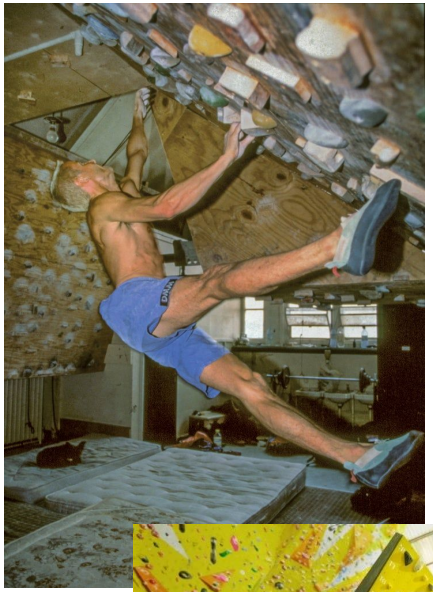
GitHub: https://github.com/davaragao/ML_Project_Climb

Moonboards

Originally founded in the 1990's, the School Room became the hardcore indoor training hub for some of Britain's most talented climbers

In 2005, Ben Moon developed a standardised wooden training board. Set at 40° with a specially designed set of resin holds called the MoonBoard.

Now available all over the world. Standardized: angle, holds, and problems. Controlled via an App



The Problem

How to classify the difficulty of a climb without having climbed it?

Why?

- To assign grades if one isn't given
- Assistance for generating new climbs
- For standardizing grades across different markets

Why is grading difficult? Grades are very subjective:

- Climbers have different strengths (finger, core, technique, upper body, flexibility, coordination, etc.)
- Climber morphology (height, wingspan, weight etc)
- Regional grading preferences (sandbagging, outdoor climbing affinity)
- Hard to grade what you can't climb, for lack of comparison

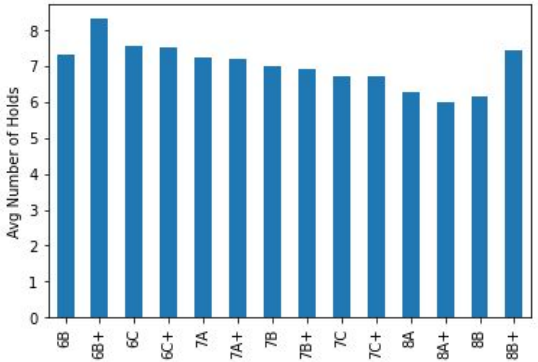
Assumptions/Hypotheses about data

- Human accuracy is between 30 and 45%
- Distance between holds is a strong predictor of grade
- Harder holds increase in frequency with grade
- Difficult problems have fewer holds

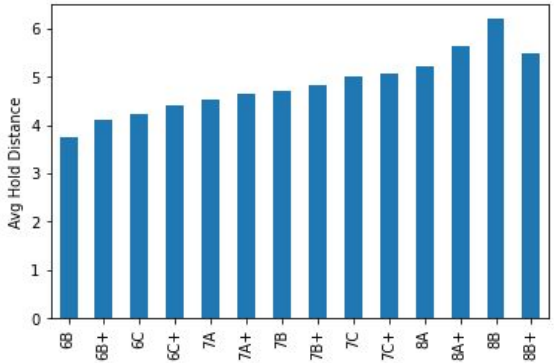
	Exactly meet with the grade
Climbing expert 1	47.6%
Climbing expert 1 (second try)	30%
Climbing expert 2	42.5%
Climbing expert 3	45%
Estimated HLP	45.0%

Source: http://cs230.stanford.edu/projects_spring_2020/reports/38850664.pdf

Number Holds vs Grade

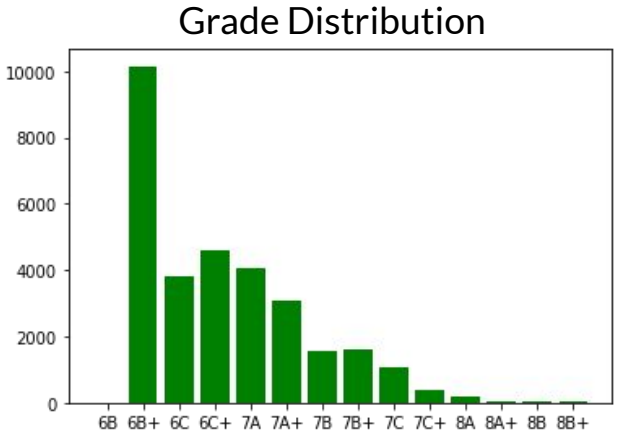


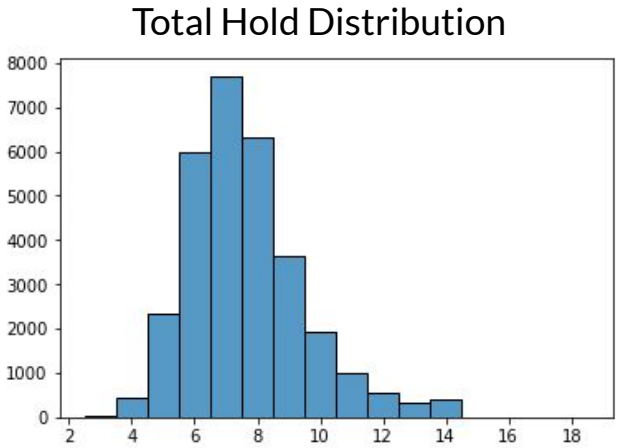
Hold Distance vs Grade



Exploratory Data Analysis

- Primary source data based on MoonBoard Web Scraping
- Total Observations: 30,636
- Features include:
  - Climb Number
  - Hold positions for route sequence
  - Number of times route was climbed
  - Web URL & Setter profile
  - Grade (Our target variable)
- Secondary data source with hold difficulty by position
- Outlier data removed based on total hold count

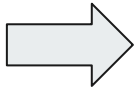




Feature Engineering & Transformations for DNN

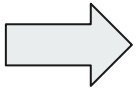
Hold Coordinates

[8 , 13]



Hold Difficulty by Hand

Left Hand: 3
Right Hand: 7



Difficulty Sequences

Min: [3.0, 3.0 , 5.0]
Avg: [3.5, 5.0, 5.5]
Max: [4.0, 7.0, 6.0]

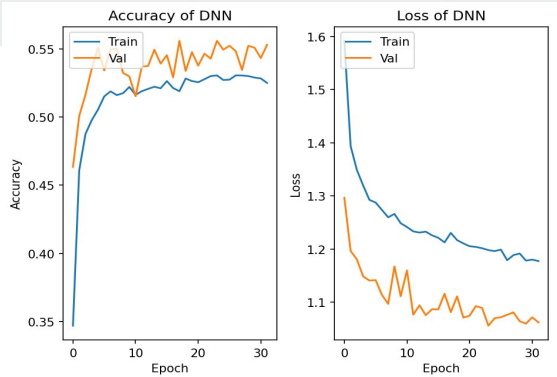
- Convert hold location sequences to difficulty sequences
- Profile route based on difficulty at start, middle, and end
- Store attributes including number of holds and most difficult hold
- Analyze hold distances across MoonBoard
- Group target variable

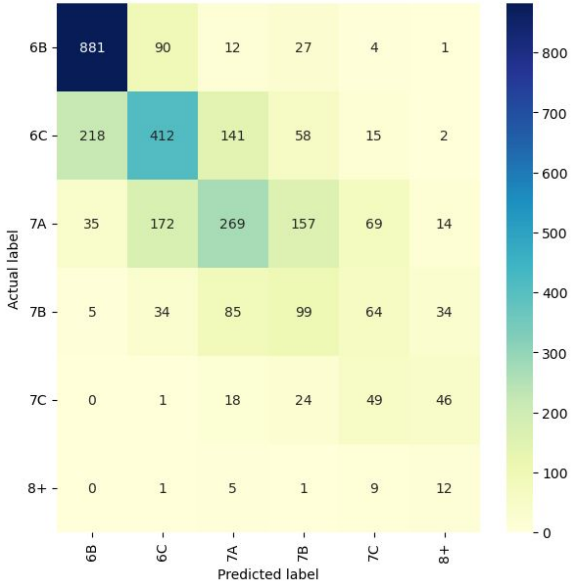
DNN Results

- Input layer, 3 hidden layers, output layer
- Dropout layers at 0.2 to prevent overfit
- Training halted at 32 epochs based on early stopping
- Adam optimizer and performance scheduling

Accuracy	
Train	52.5%
Validation	55.3%
Test	56.2%

Test Data Classification Report				
Category	**Precision**	**Recall**	**F1-Score**	**Support**
6B	0.77	0.87	0.82	1015
6C	0.58	0.49	0.53	846
7A	0.51	0.38	0.43	716
7B	0.27	0.31	0.29	321
7C	0.23	0.36	0.28	138
8+	0.11	0.43	0.18	28
Accuracy			56%	





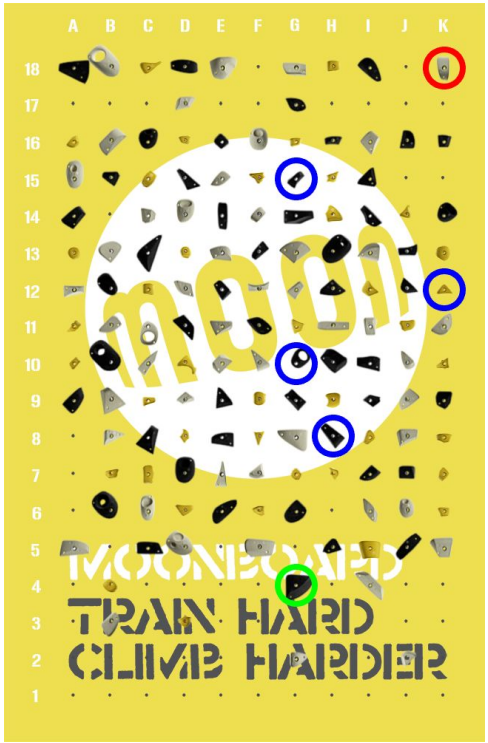
Feature Engineering & Transformations for CNN

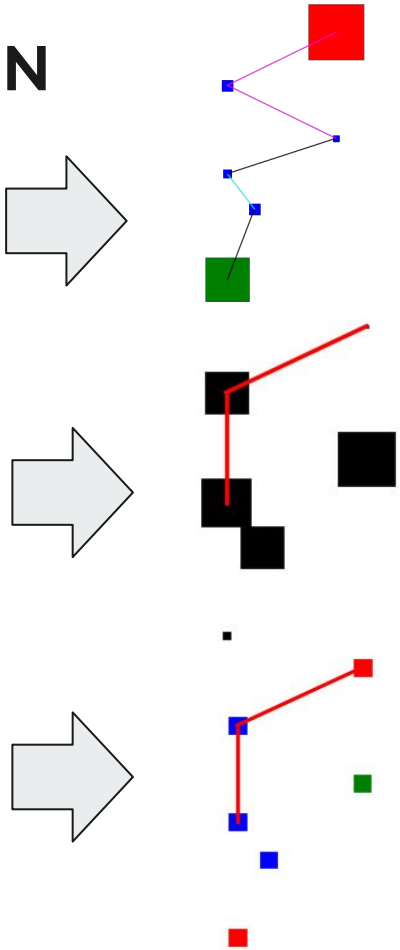
Scraped Data in JSON:
'start': [[6, 3]],
'mid': [[7, 7], [6, 9], [10, 11], [6, 14]],
'end': [[10, 17]],

Square Colors
{Green==Easy, Blue==Avg, Red==Hard}

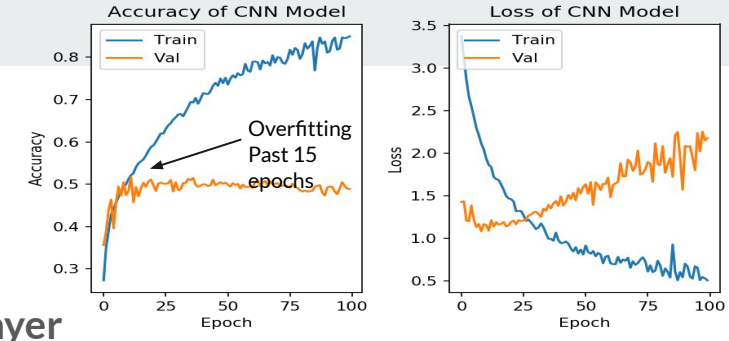
Square Size
Scaled proportionally by difficulty of hold

Line Colors
{Closest Hold is Far==Red}





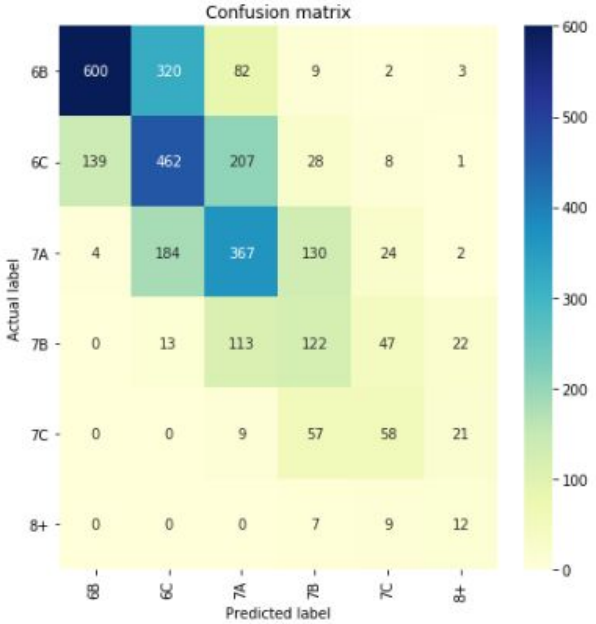
CNN Results



- Input layer, 4 Conv2D/4MaxPooling 2D layers, output layer
- Dropout layers at 0.5 to prevent overfit
- Training halted at 12 epochs based on early stopping
- Adam optimizer and performance scheduling

Accuracy	
Train	54.5%
Validation	52.9%
Test	54.0%

Test Data Classification Report				
Category	**Precision**	**Recall**	**F1-Score**	**Support**
6B	0.81	0.59	0.68	1016
6C	0.47	0.55	0.51	845
7A	0.47	0.52	0.49	711
7B	0.35	0.38	0.36	317
7C	0.39	0.4	0.4	145
8+	0.2	0.43	0.27	28
Accuracy			54%	



Model Selection: DNN

- More flexible in adding new features
- Less parameters
- Faster Training
- Slightly better performing

Properties	CNN	DNN
Feature Engineering	Limited	Unlimited
# Params	394.5K	2.2K
Seconds per Epoch	350	4
Test Accuracy	0.54	0.56

Future Work

- Better data cleaning (removing “impossible” climbs, removing circuits, removing rule-based climbs (ie. hands only, no matching, etc))
- Classifying holds based on use: hand only, foot only
- Integration with Moonboard App for making the building of a climb less time consuming
- Build function for encoding climbs into movement sequences for use in RNN/LSTM model
- Hand sequencing to better approximate hold difficulty
- Combine CNN model output as DNN input feature