

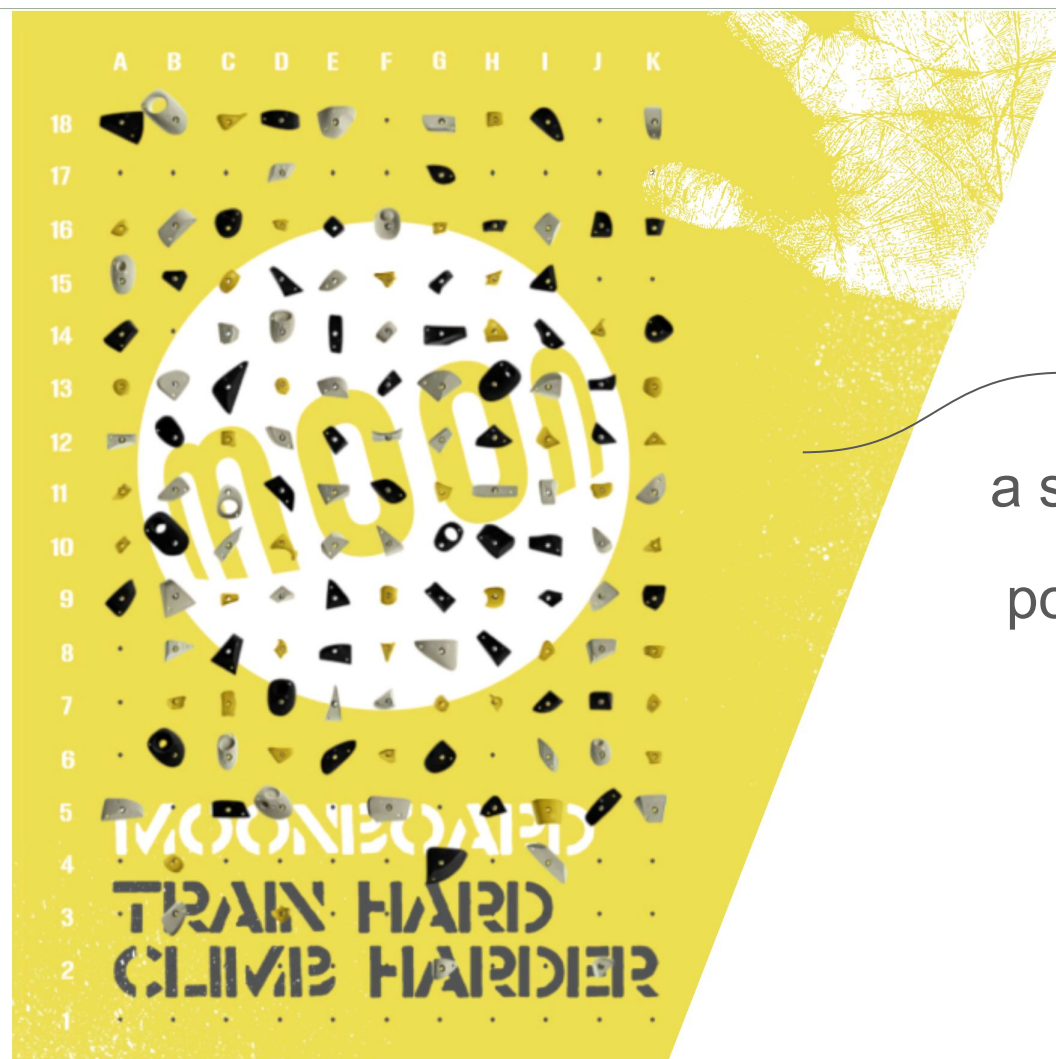
MoonBoard

The Erdős Institute
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Group Members

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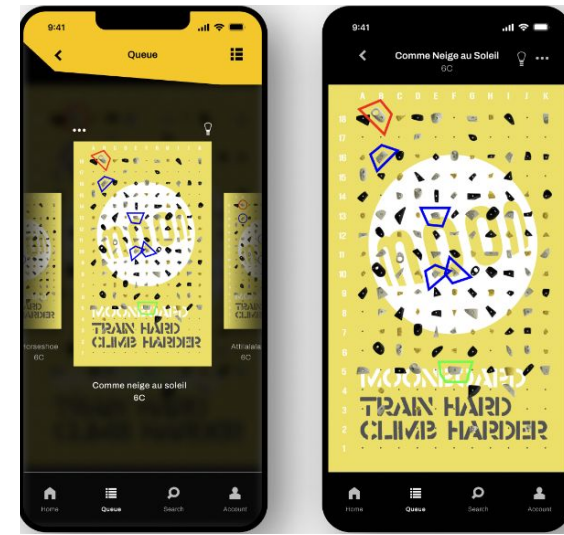
MoonBoard

a standardized climbing wall with
holds set at a specific
position/orientation on the board

Introduction to the MoonBoard

- A proprietary climbing wall for bouldering.
- Standardized dimensions, standardized holds and hold positions.
- Associated app contains 100,000+ human-designed climbing routes (“problems”), listed by difficulty score (“grade”).

**There are several versions of the MoonBoard. We’re only considering the original (2016) version.*

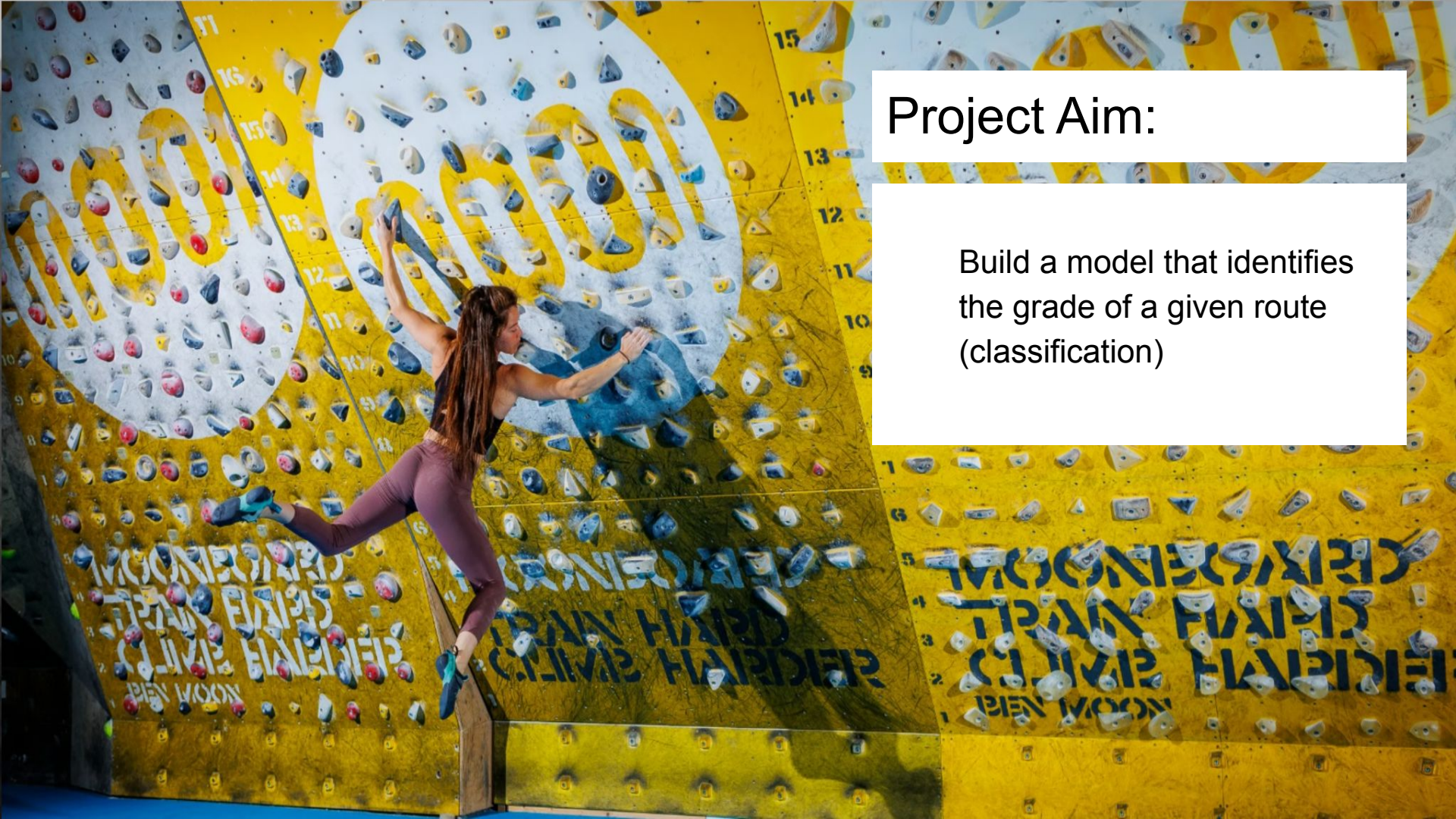


An intermediate hold lit by a blue LED, indicating its use on a problem.

Grading System

- Grade system: 6B, 6B+, 6C, 6C+, 7A, ..., 8B+
- There is often a consensus around grades assigned to MoonBoard problems





Project Aim:

Build a model that identifies the grade of a given route (classification)

Dataset & Features

Raw dataset (in JSON format online) lists ~60,000 problems, each having

- **Grade information:**
 - Grade intended by creator
 - Grade given by other app users
- **Route information:**
 - List of holds you're allowed to use
 - Where to start and end
- **Extraneous information:**
 - Number of users who've done the problem
 - Average quality rating by users
 - Whether it's an official "benchmark"

Data Cleaning & Preprocessing

- Convert grades 6B–8B+ to integers 0–13
 - '6B' ↔ 0
 - '6B+' ↔ 1
 - '6C' ↔ 2
 - ...
 - '8B+' ↔ 13
- Ignore low-quality data, i.e. problems with:
 - Impossible configurations (e.g., A6 is not a hold in the 2016 model, so problems with A6 were removed)
 - Fewer than 2 users having done it
 - User rating 3 or below



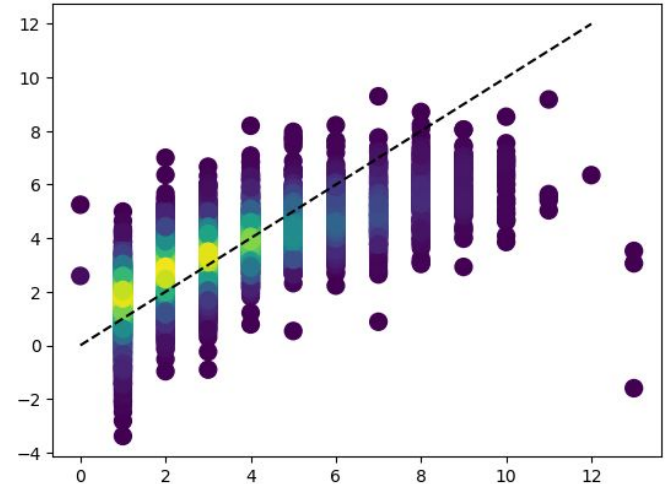
Baseline Model

Baseline model:

- One feature for each hold, valued as 0 or 1 (1 if it's included in the problem).
- (Ignore the start/end locations and the physical layout of the board).
- Apply linear or logistic regression.

Results:

- Mean squared error: 1.95 (linear), 2.11 (logistic)
- Accuracy rate (exact grade match): 30% (linear), 40% (logistic)
- Accuracy rate (within one grade): 75% (both)



Feature Engineering

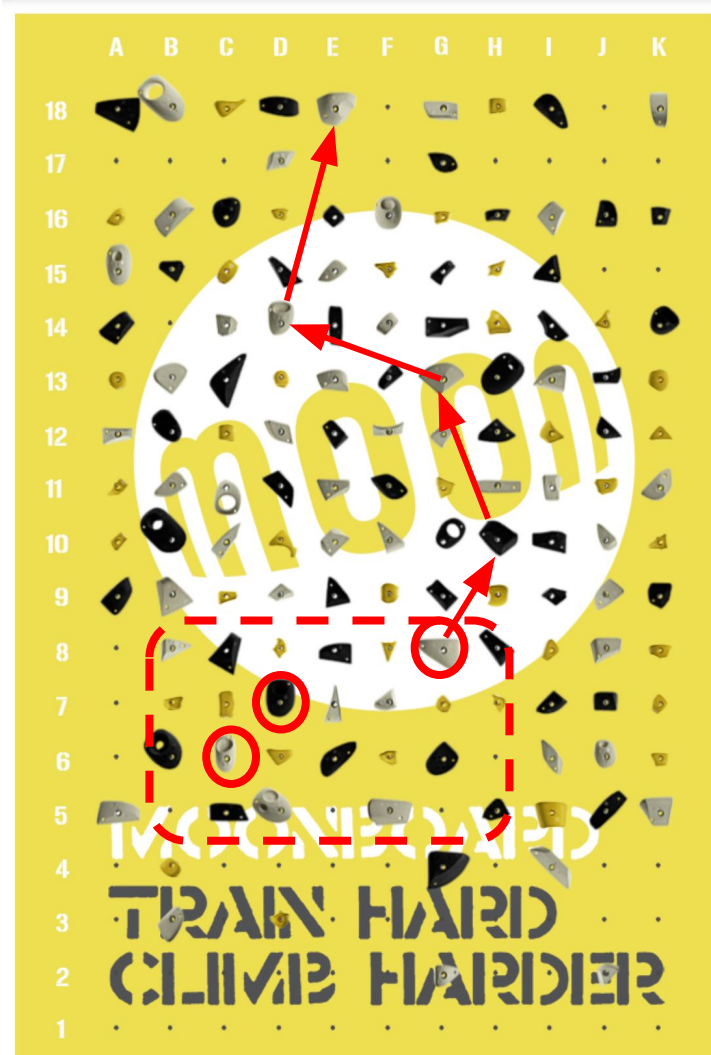
Added synthetic features based on board layout (e.g. size of largest vertical gap, standard deviation of horizontal coordinates, ...)

Attempted to capture sequential information of climbing routes.

Obtain a heuristic ordering of holds.

Construct a bag of bigrams using these ordered sequences

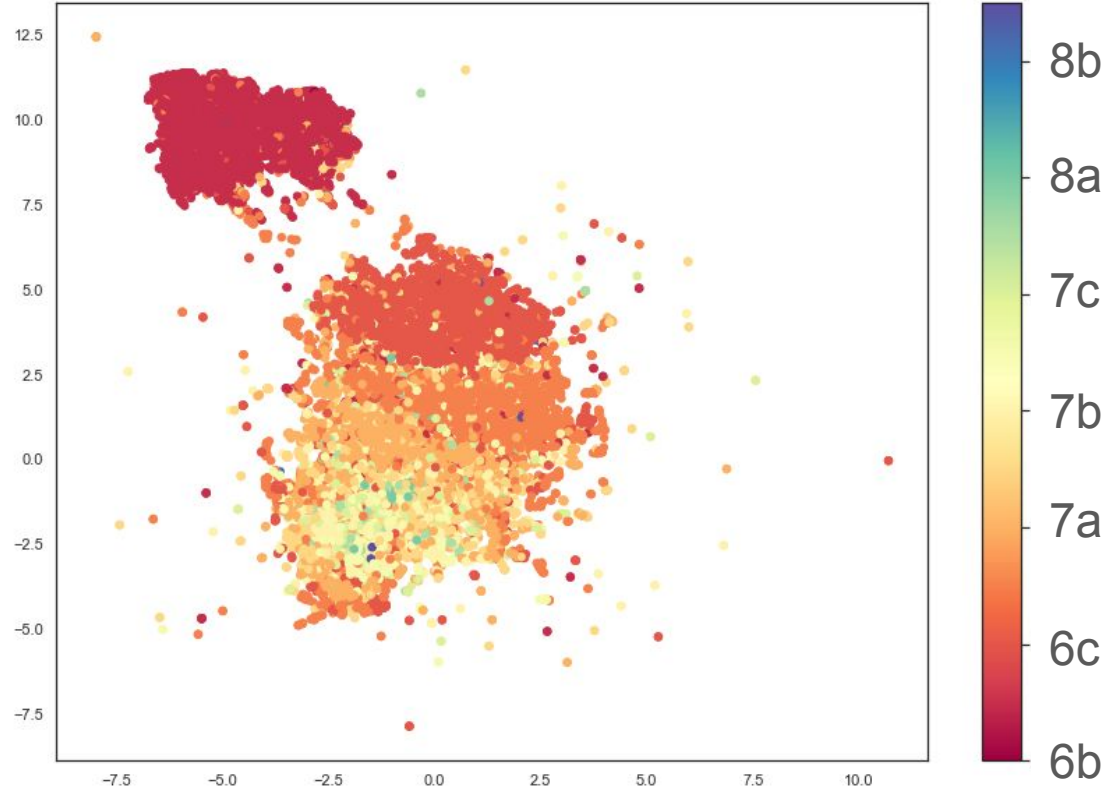
Too many dimensions ~ 19000.



Feature Engineering

Use UMAP to embed in lower dimensional space.

Unfortunately, features obtained in this way did not significantly improve model accuracy



Modeling Approaches

XGBoost Regressor with numerical grades

- Cross-validation suggestions: max tree depth = 3 or 4, number of trees = 200 or 300
- Model gives continuous estimate, get exact grade prediction by rounding

Neural Network Classifier

- Model gives the probability of each class
- Model parameters:

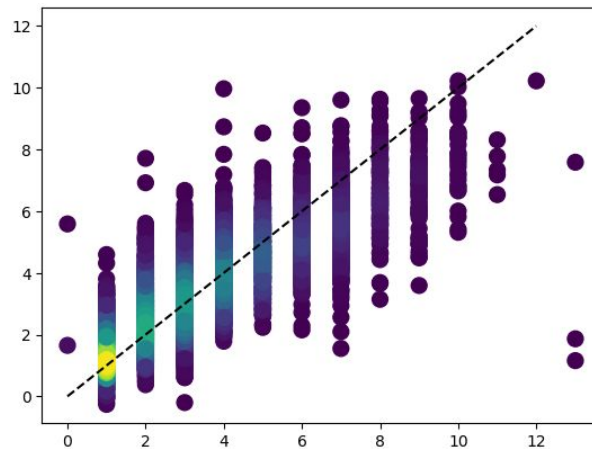
Hidden layers	Learning Rate	Dropout	Epochs
[1000, 100,20,10]	0.05	0.5	300

Results

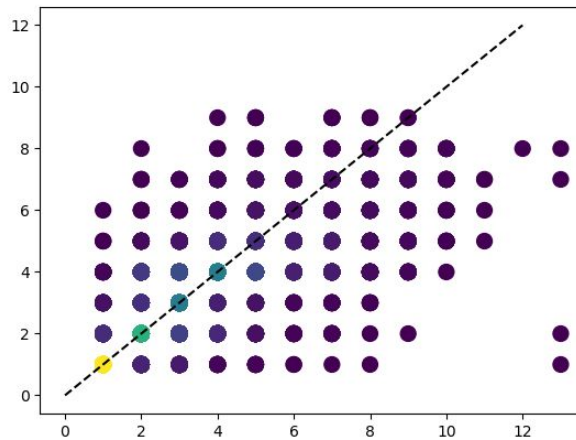
	Loss function	Accuracy	Accuracy (within 1)
XGBoost Regressor	MSE = 1.37	40%	83%
Neural Network	CE = 1.56	51%	77%

For comparison: Human climber guess accuracy is ~45%, or ~85% within 1 grade

XGBoost Regressor:



Neural Network:



Limitations & Future Research

- Limitations:
 - Conflicting classification (Different users assigning different grades for same problem)
 - Limited range of grades available (Only 6B – 8B+ are used)
- Future analysis:
 - Expand database of problems to include multiple models of MoonBoard
 - 2017, 2019, & 2024 models
 - 25° & 40° setup
 - Possible alternative cleaning methods (e.g. handle duplicates differently)
 - Try convolutional neural networks
 - Include MSE in neural networks models

Thank You!



Roman, Steven, Alec, and the rest of the staff at the Erdős
Institute

Gleb Zhelezov (our mentor)



Moon Climbing