ETSEIB

Difficulty Grading of a Kilter Board Route

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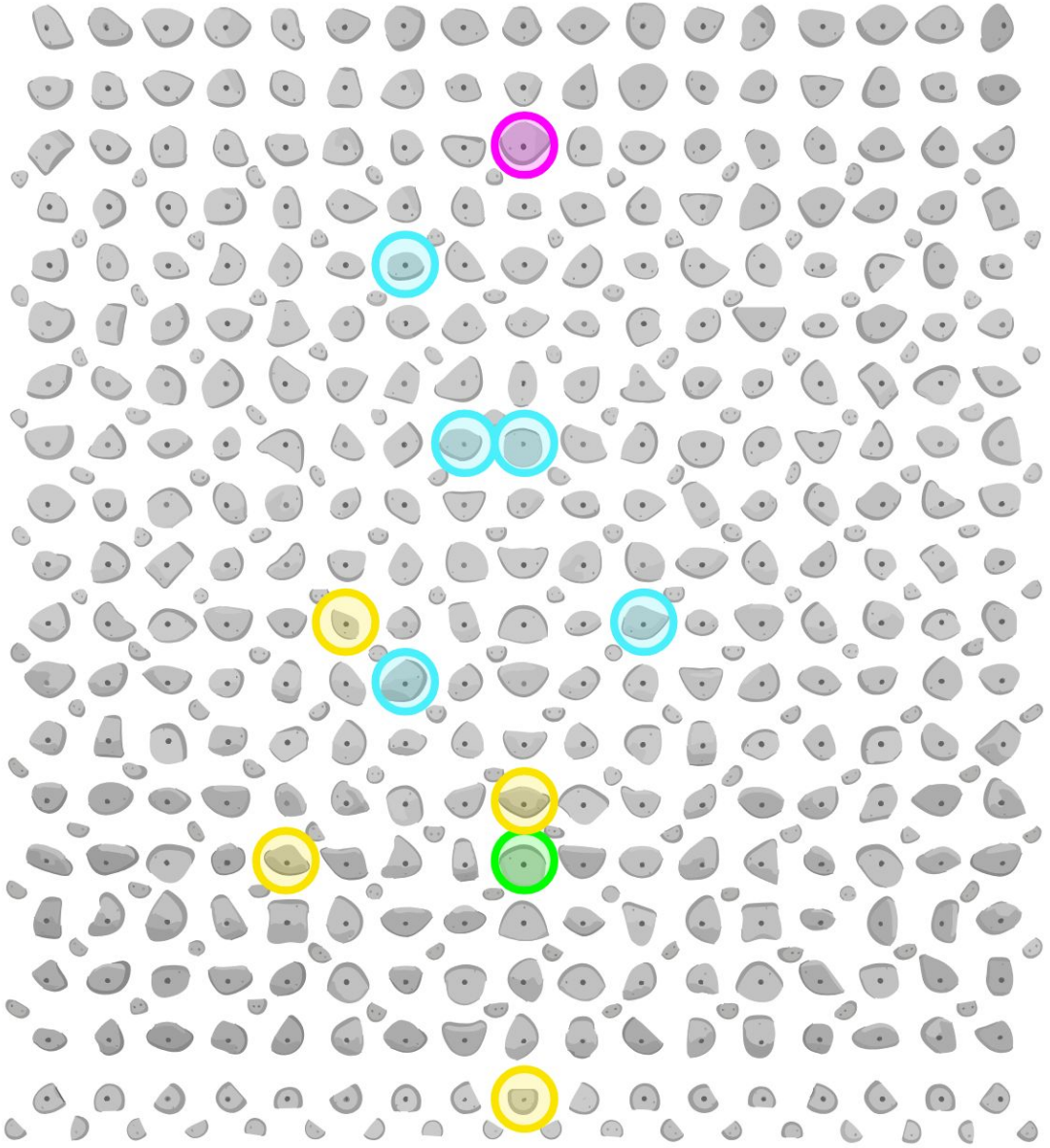
Problem Statement

- What is the Kilter Board?
- Why is difficulty grading important?
- How is difficulty assessed?
- The problem: subjective, inconsistent ratings
- Goal: Build a **machine learning model** to **predict route difficulty**

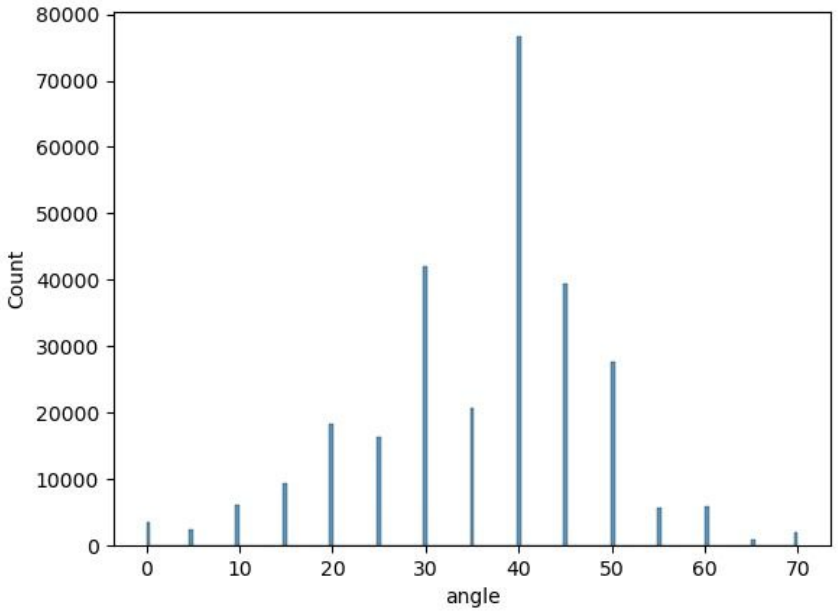
Example

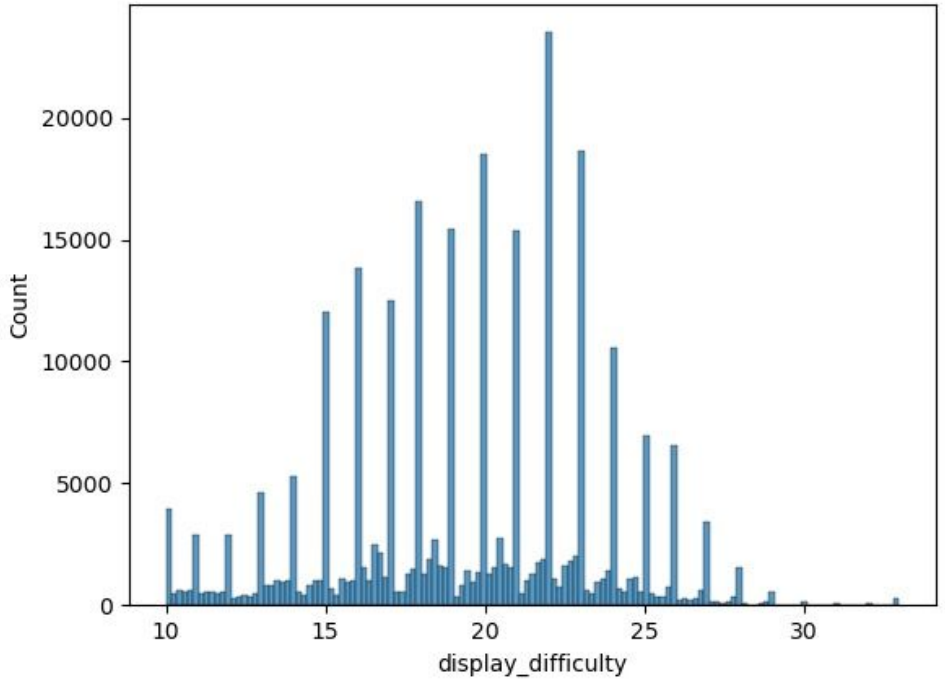
- Name: Sour Gummi Worms
- Number of holds: 11
- Wall angle: 40°
- Difficulty: 5c/V2 (15.00)
- Number of logged ascensions: 32234



Dataset Description

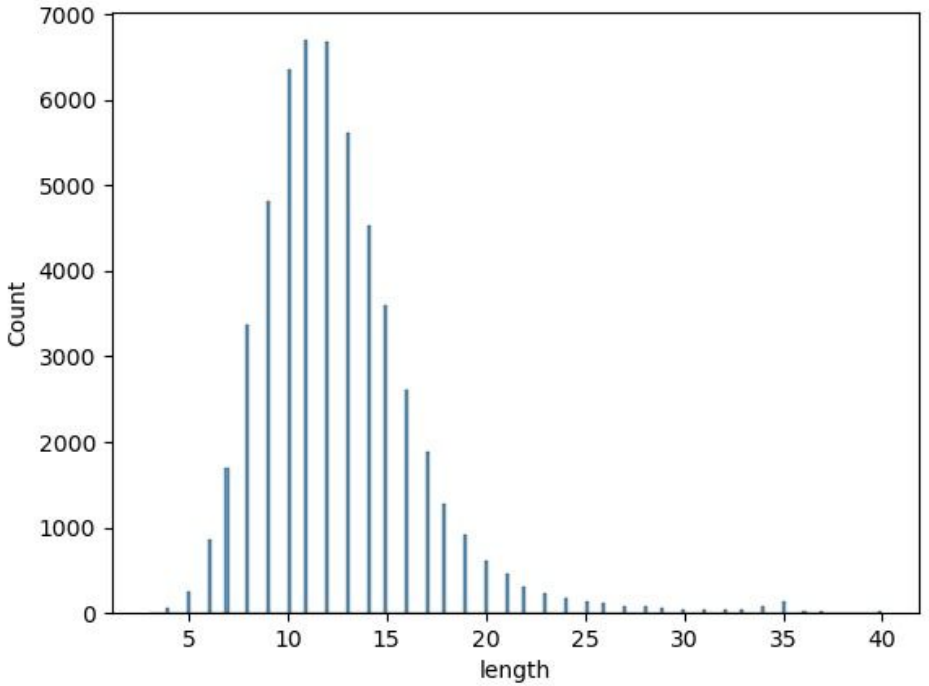
- Data source: Kilter Board API via mobile app
- Size: 50,000+ routes
- Filtering criteria (e.g., at least 5 user completions)
- How difficulty is rated (e.g., 1–39 scale, V-scale conversion)
- Factors influencing difficulty (wall angle, hold type/position, etc.)





Preprocessing

- Features used per hold (x/y, start/finish, foothold) → leads to 201 features/climb
- Cap at 20 holds → 101 total features/climb
- Use of **PCA** for dimensionality reduction → 2 features/hold (99.99%) → 41 features/climb



Train & Test Data

- 80/20 train/test split
- Shapes: `Xtrain (43164×41)`, `Xtest (10792×41)`
- Goal: Generalize to unseen climbs

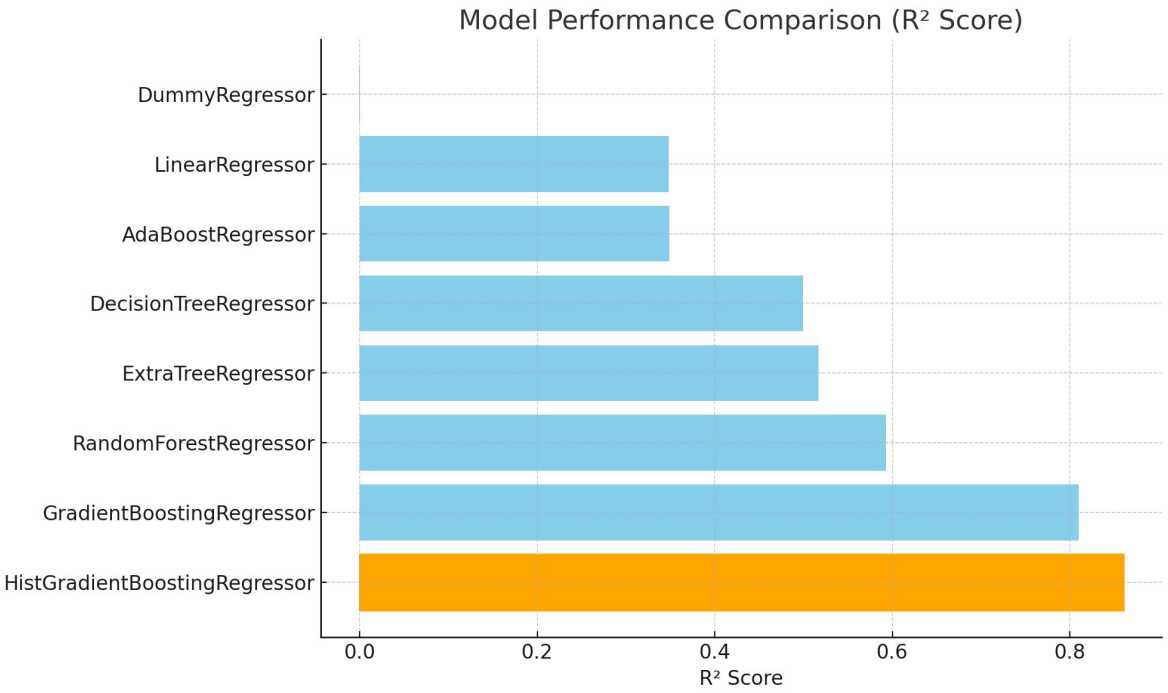
Difficulty Rating Prediction

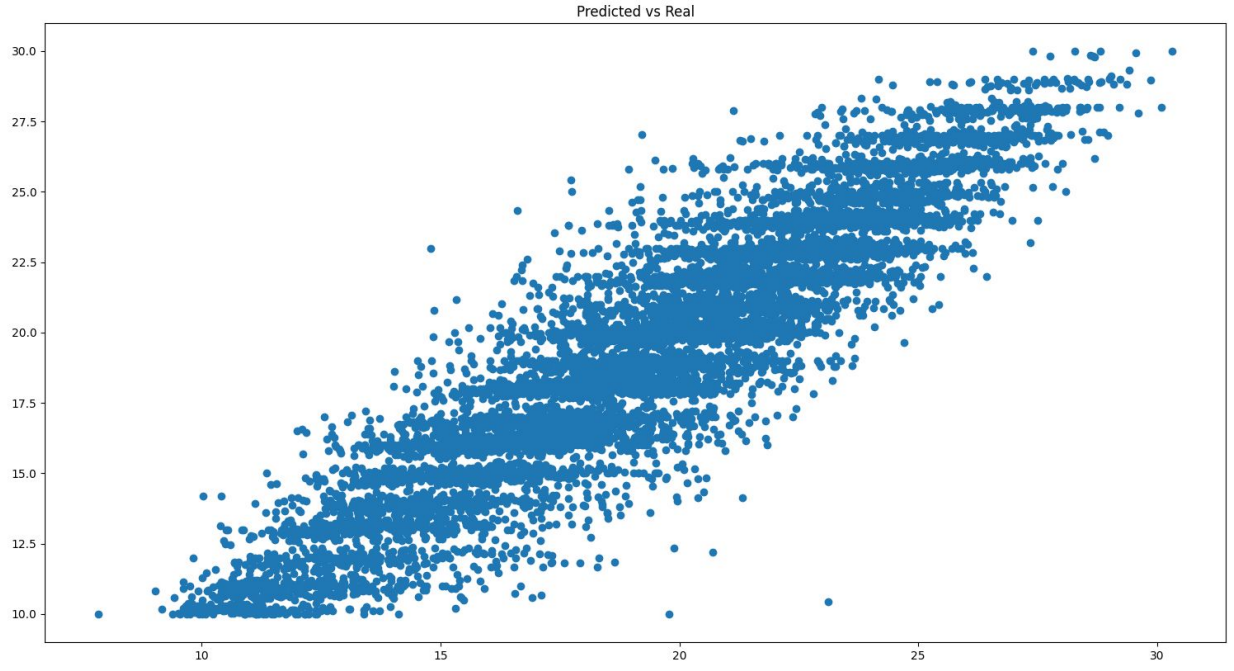
- Models tested:
  a. Dummy Regressor (baseline)
  b. Linear Regression
  c. Decision Tree
  d. Random Forest
  e. Extra Trees
  f. Gradient Boosting
  g. Histogram-based Gradient Boosting
- Hyperparameter tuning via Grid Search

MODEL PERFORMANCE WITH R^2 SCORES

Model	R^2 Score
Dummy Regressor	-0.0006
Linear Regressor	0.348
Decision Tree Regressor	0.499
Random Forest Regressor	0.593
Extra Tree Regressor	0.517
Gradient Boosting Regressor	0.810
Hist Gradient Boosting Regressor	0.860

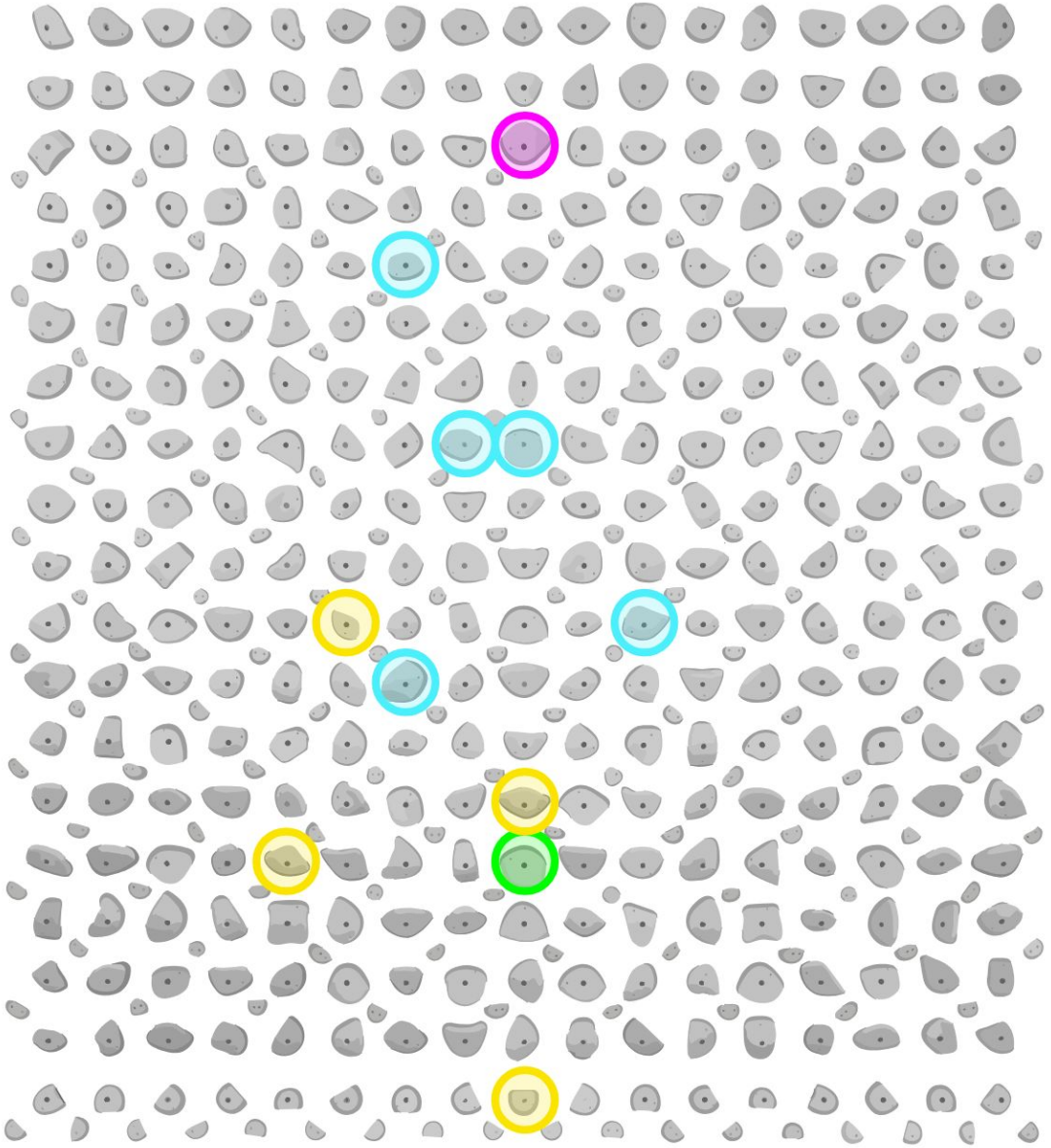
Results


Model Performance Comparison (R² Score)
DummyRegressor
LinearRegressor
AdaBoostRegressor
DecisionTreeRegressor
ExtraTreeRegressor
RandomForestRegressor
GradientBoostingRegressor
HistGradientBoostingRegressor
0.0
0.2
0.4
0.6
0.8
R² Score


Predicted vs Real
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
10
15
20
25
30

Example

- Name: Sour Gummi Worms
- Original difficulty: 5c/V2 (15.00)
- Linear Regression estimation: 6b+/V4 (18.84)
- Decision Tree estimation: 6c/V5 (20.25)
- RandomForest estimation: 6b+/V4 (18.60)
- ExtraTree estimation: 6b/V4 (18.01)
- GradientBoosting estimation: 6a/V3 (15.71)
- HistGradientBoosting estimation: 5c/V2 (15.08)



Conclusion

- Value added:
  a. Objective grading
  b. Better training & benchmarking
  c. Tools for climbers and gyms
  d. Metric for further AI development in this field

Future Work

- Potential extensions:

  a. Use of other type of features (type of hold, distance between holds)

  b. Include user demographic or anthropometric data

  c. Time-to-complete metrics

  d. Graph-based Deep Learning Models (e.g. GNNs) for preserving and leveraging spatial information.

  e. Real-time route grading in the app