Evaluating Bouldering Route Difficulty

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Problem Statement

In rock climbing, the difficulty of climbing routes are classified using a grade given by climbers. Generally, the grades depend on the length or style of the route, the challenge of the required moves, and the estimated danger of the climbing conditions. As a result, climbing grades are subjective as they depend on collective human assessment. It doesn't help that many existing grade scales are also ambiguous when it comes to distinguishing between approximate difficulty levels. The lack of object route assessments presents an opportunity to build a model which can accurately predict the the difficulty of a route, with the potential to benefit climbers' performance, particularly when training) and aid in improving the ambiguity of standardized scales.

With this project, we would explore predicting the climbing grade of Bouldering problems; routes that are designed for free climbing and do not involve the use of ropes or a harnesses. Additionally the routes are typically no higher than 6 metres. For this project, we propose the use of the Hueco scale (V0 - V17).

Data Collection and Data Processing

To explore this task, we would use climbing route data collected from moonboard.com. Moonboards are a standardized climbing wall made up of 142 rock holds on an 18x11 grid. They are most often used for indoor Bouldering training. Moonboard climbers utilize an app to load a problem route to the board, the sequence of holds marked by illuminated LEDs, so a large dataset of problems have already been created by Moonboard and community users. For reference, over 30k problems were scraped by Duh & Chang in their 2021 work using RNN models for classification and route generation [Duh and Chang, 2021].

The Moonboard route can be effectively encoded as a $0, 1^{(}18 \times 11)$ matrix to serve as a graphical representation of the board, which can then be one-hot encoded (or multi-hot) to prepare the representation for input to the classification model. Essentially, the encoded climbing routes will allow the model to look for patterns and similarities between climbing grade classes and learn to distinguish problems, since the climbing routes will follow a standard format as described above.

Approaches

We would explore this classification task by experimenting with a more advanced convolution neural network architecture than in previous works, and apply this architecture to the Moonboard dataset for training and testing. The Moonboard dataset will first need to be scraped and prepared with basic cleaning and pre-processing (e.g. standardizing the grade scale to use Hueco instead of a European scale). Data will need to undergo a hot-encoding process or in preparation for its input to a neural network. The neural network architecture will be designed and implemented to be applied to the climbing route data, with experiments addressing different activation functions, learning rates, and other parameters will be conducted to illustrate the network's performance and fine-tuning processes. Following experimental results, we will revisit our experiment design (or network architectures) as necessary with time permitting to investigate the performance more closely (e.g. look to what sorts of climbing routes were often misclassified, the impact of learning rates, etc.). Results from our experiments will be discussed thoroughly in our final report, with special attention to illustrating the theoretical understanding of the problem and the performance of our models.

Related Works

CNN for Climbing Route Classification

Dobles et al. (2017) employed and evaluated Naives Bayes, softmax regression, and Convolutional Neural Network classifiers to attempt to determine the difficulty grade of climbing routes, specifically using a dataset collected from Moonboard.com to standardize the data. They yielded the following accuracies for each classifier respectively, 34.0% 36.5% 34.0% [Dobles et al., 2017].

RNN for Route Classification and Generation

Duh & Chang (2021) employed RNN architectures to explore classifying Moonboard climbing route grades and to generate new Moonbaord routes. Their 'GradeNet' architecture achieved 46.7% accuracy upon testing [Duh and Chang, 2021].

Graph Convolutional Neural Networks for Route Classification

Tai et al. (2020) applied Graph Convolutional Neural Networks (GCN) architectures previously used in NLP applications to classifying the climbing route grade of Moonboard problem sets, with their top model achieving an average AUC score of 0.73 across all classes [Tai et al., 2020].

References

[Dobles et al., 2017] Dobles, A., Sarmiento, J. C., and Satterthwaite, P. (2017). Machine learning methods for climbing route classification.

[Duh and Chang, 2021] Duh, Y. and Chang, R. (2021). Recurrent neural network for moonboard climbing route classification and generation. *CoRR*, abs/2102.01788.

[Tai et al., 2020] Tai, C.-H., Wu, A., and Hinojosa, R. (2020). Graph neural networks in classifying rock climbing difficulties.