DeepClimb: CNN for Automatic Bouldering Route Difficulty Assessment

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Introduction

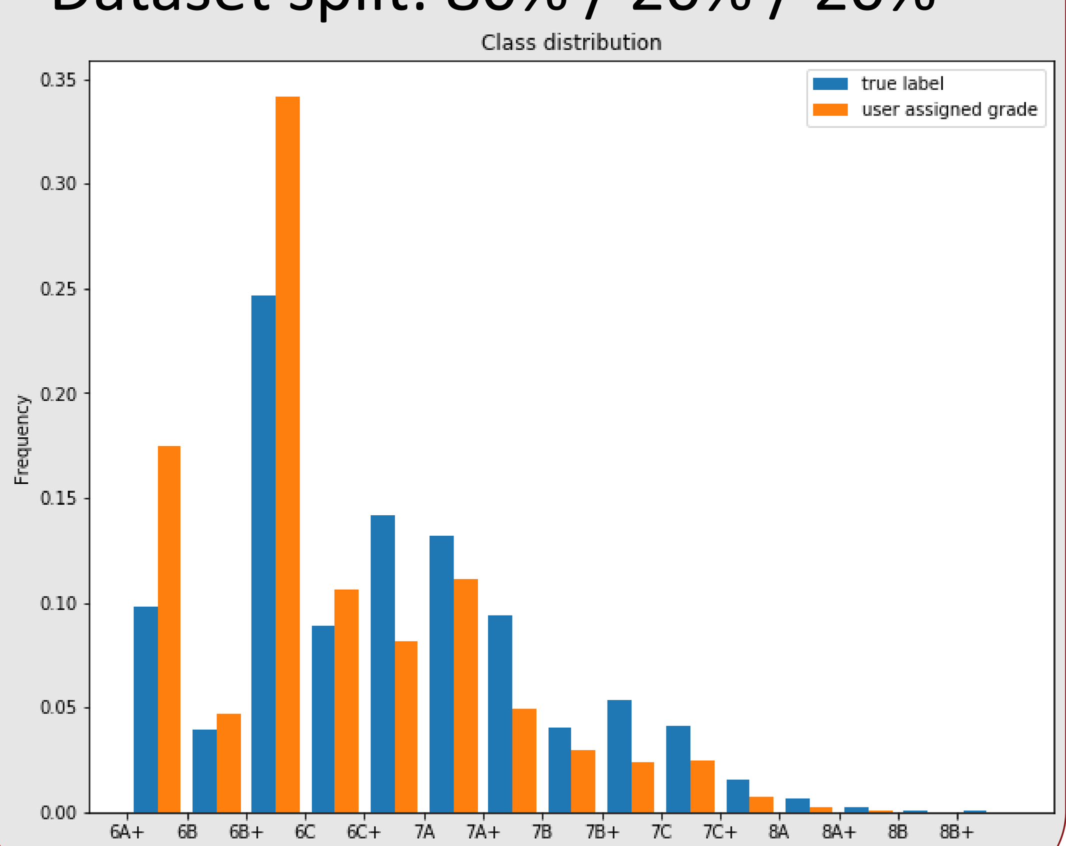
Problem

- Task: Classification of bouldering routes C = 15
- Custom dataset: MoonBoard

Data

Nb of examples: 34,795

Dataset split: 80% / 20% / 20%



Example representation

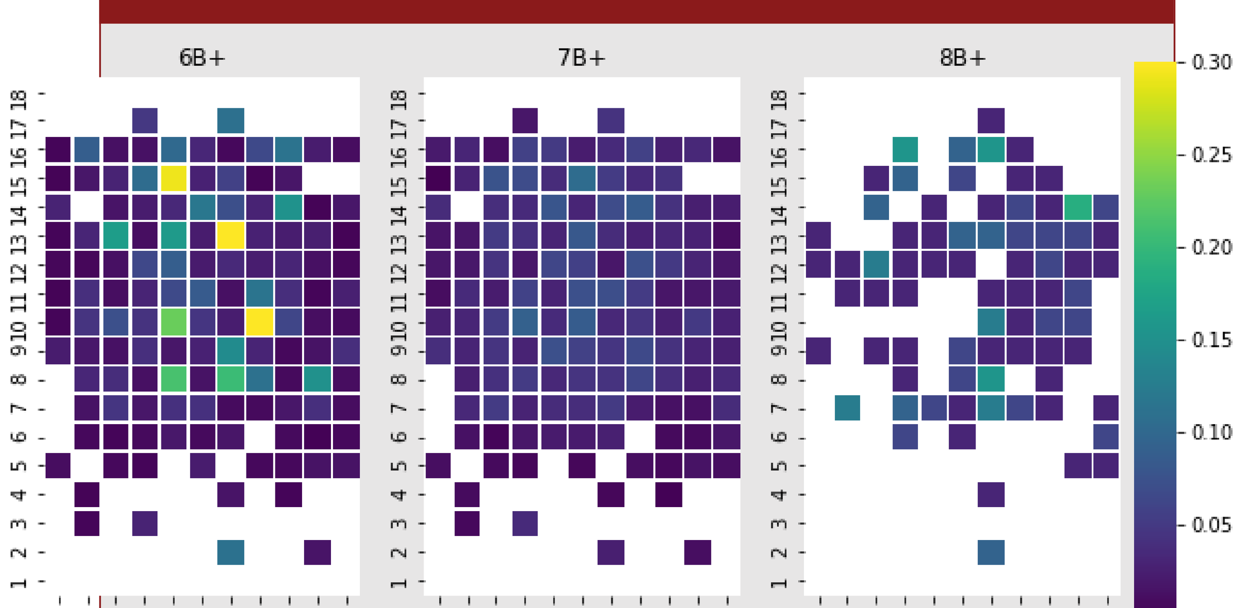


Figure 2: Heatmap of hold frequency for easy, intermediate and hard routes

Baseline: Naive Bayes

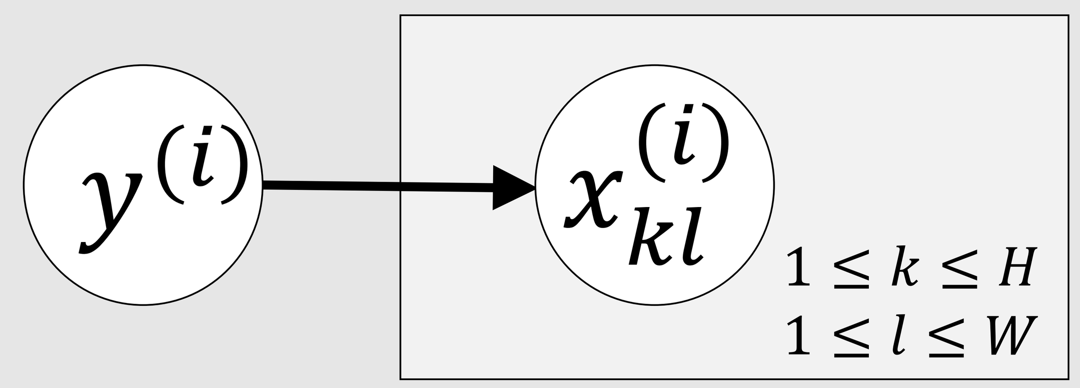


Figure 3: Naive Bayes model

$$w_j = p_j^{-k}, 1 \leq j \leq C$$

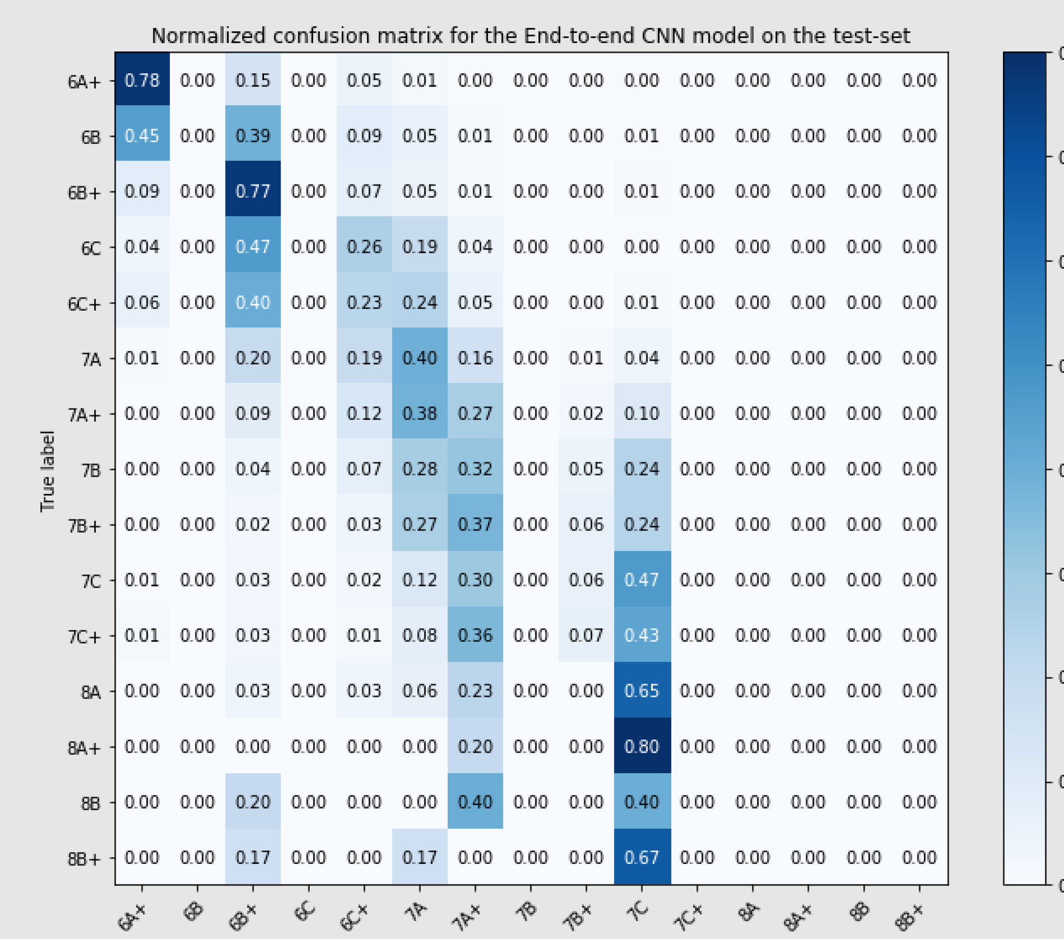
Equation 1: Example weighting scheme

End-to-end CNN

Layer	Filter Dimensions	Activation Dimensions
INPUT	None	384 x 256 x 3
CONV3-8-MAX	8 x 3 x 3 x 3	192 x 128 x 8
CONV3-8-MAX	8x 3 x 3 x 8	96 x 64 x 8
CONV3-16-MAX	16 x 3 x 3 x 8	48 x 32 x 16
CONV3-16-MAX	16 x 3 x 3 x 16	24 x 16 x 16
CONV3-32-MAX	32 x 3 x 3 x 16	12 x 8 x 32
CONV3-32-MAX	32 x 3 x 3 x 32	6 x 4 x 32
CONV3-64-MAX	64 x 3 x 3 x 32	3 x 2 x 64
CONV3-64-AVG	64 x 3 x 3 x 64	1 x 1 x 64
CONV1-15	15 x 1 x 1 x 64	15

$$CE = -\frac{1}{m}\sum_{i=1}^{m}\sum_{1 \leq j \leq C} y_j^{(i)} \log(\text{softmax}(o^{(i)})_j)$$

Equation 2: Cross-entropy loss



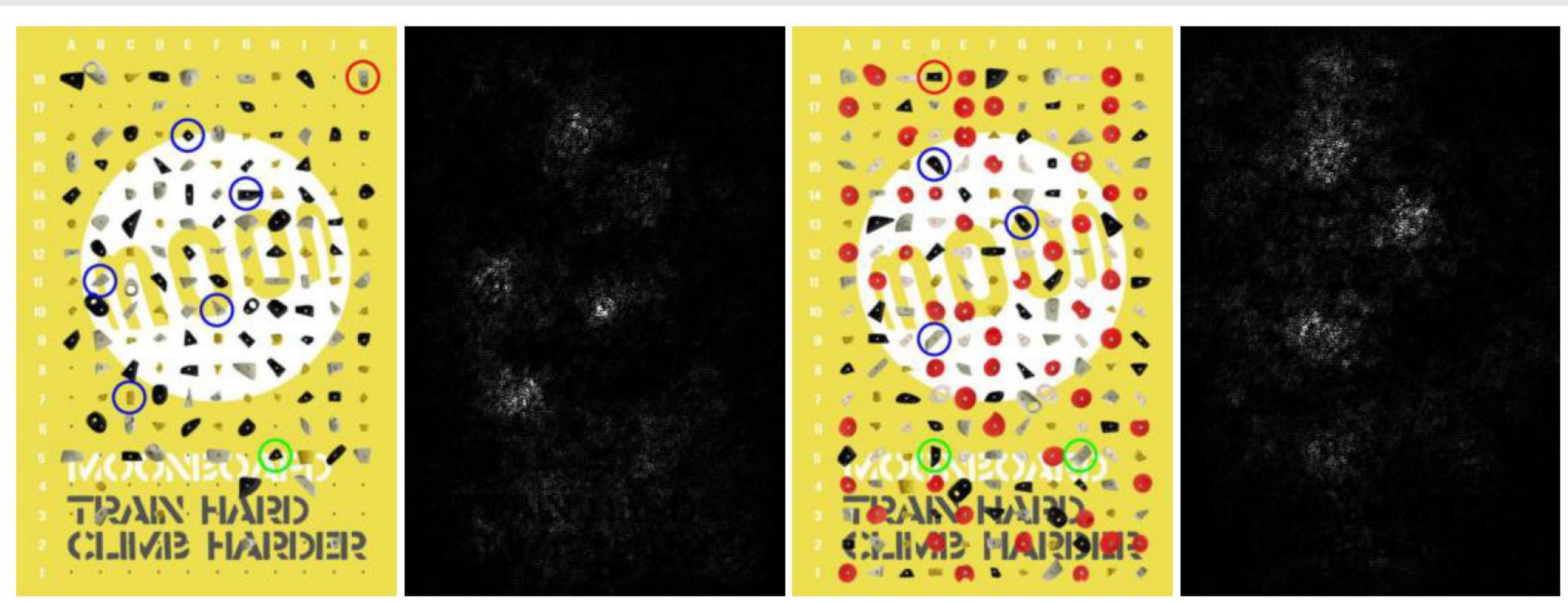


Figure 4: Validation set examples with their saliency maps computed with the end-to-end CNN model. Left: an example from the 2016 version of the MoonBoard. Right: an example from the 2017 version of the MoonBoard. In the saliency maps, white pixels indicate high absolute loss gradient with respect to this pixel of the input image.

Results (validation)

Model	Acc (%)	MAE
Naive	32	2.4
Softmax (Dobles et al. [1])	36	1.4
Naïve Bayes (k = 6)	37	1.6
End-to-end CNN	**40**	**1.2**

Conclusion

- **Outperforms the state-of-the art accuracy (40%)** and provides a good grade "first guess"
- **Robust to different wall configurations**
- Usefulness of visual information

References

[1] A. Dobles. Machine learning methods for climbing route classification. 2017.

[2] L. Kempen. A fair grade: assessing difficulty of climbing routes through ML. 2018.

[3] F. Kosmalla, F. Daiber, and A. Krüger. Climbsense: Automatic climbing route recognition using wrist-worn inertia measurement units. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, CHI '15, pages 2033–2042, New York, NY, USA, 2015. ACM.