

1. Background

Object detection systems require extensive labeled data for training, which is time-consuming and labor-intensive. This study investigates whether **grouping classes** can improve model accuracy and reduce **labelling effort**.

2. Research questions

1. Can classification accuracy be increased without extra labelling effort?
2. Can labelling effort be reduced while maintaining accuracy?

3. Methodology

Experiments were conducted using the Pascal VOC 2012 dataset, focusing on ten classes grouped into five semantic pairs which are depicted in figure 1.

- The experiments conducted include:
- Baseline models versus hierarchical structures
 - 2-layered and 3-layered hierarchical trees
 - predicting grouped classes

Figure 1: Hierarchical structure with semantically grouped classes. Used in experiment 1, 2 and 3

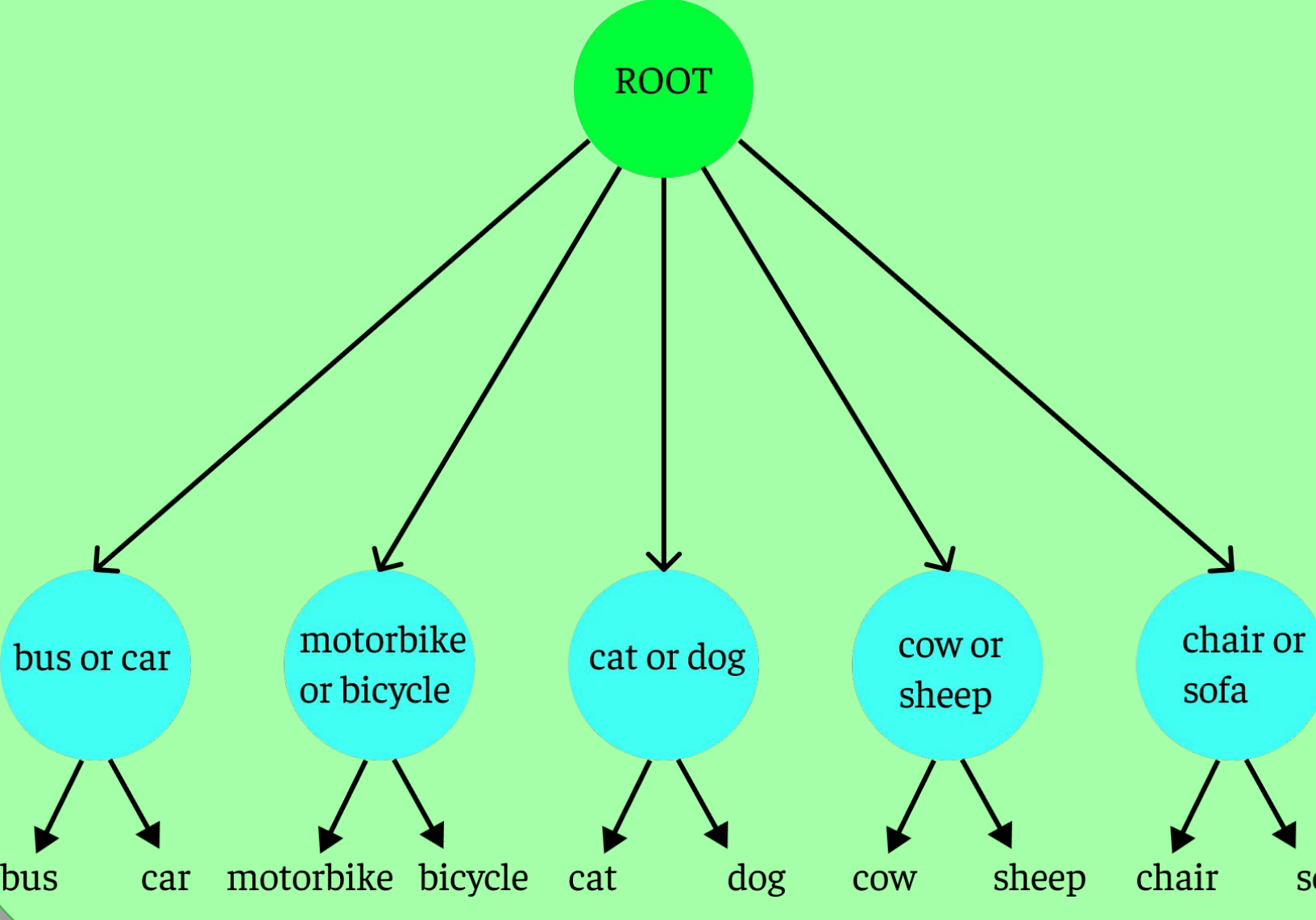
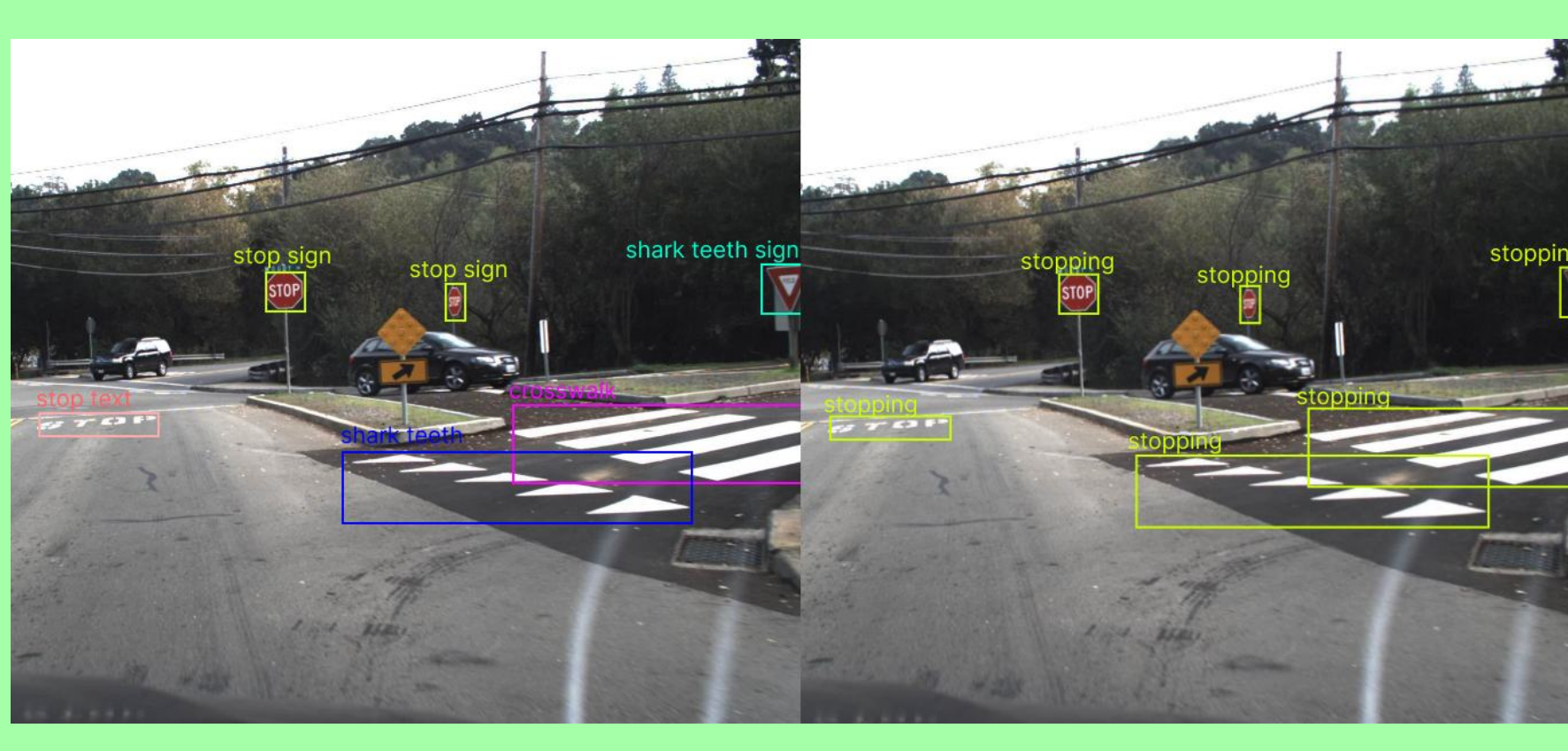
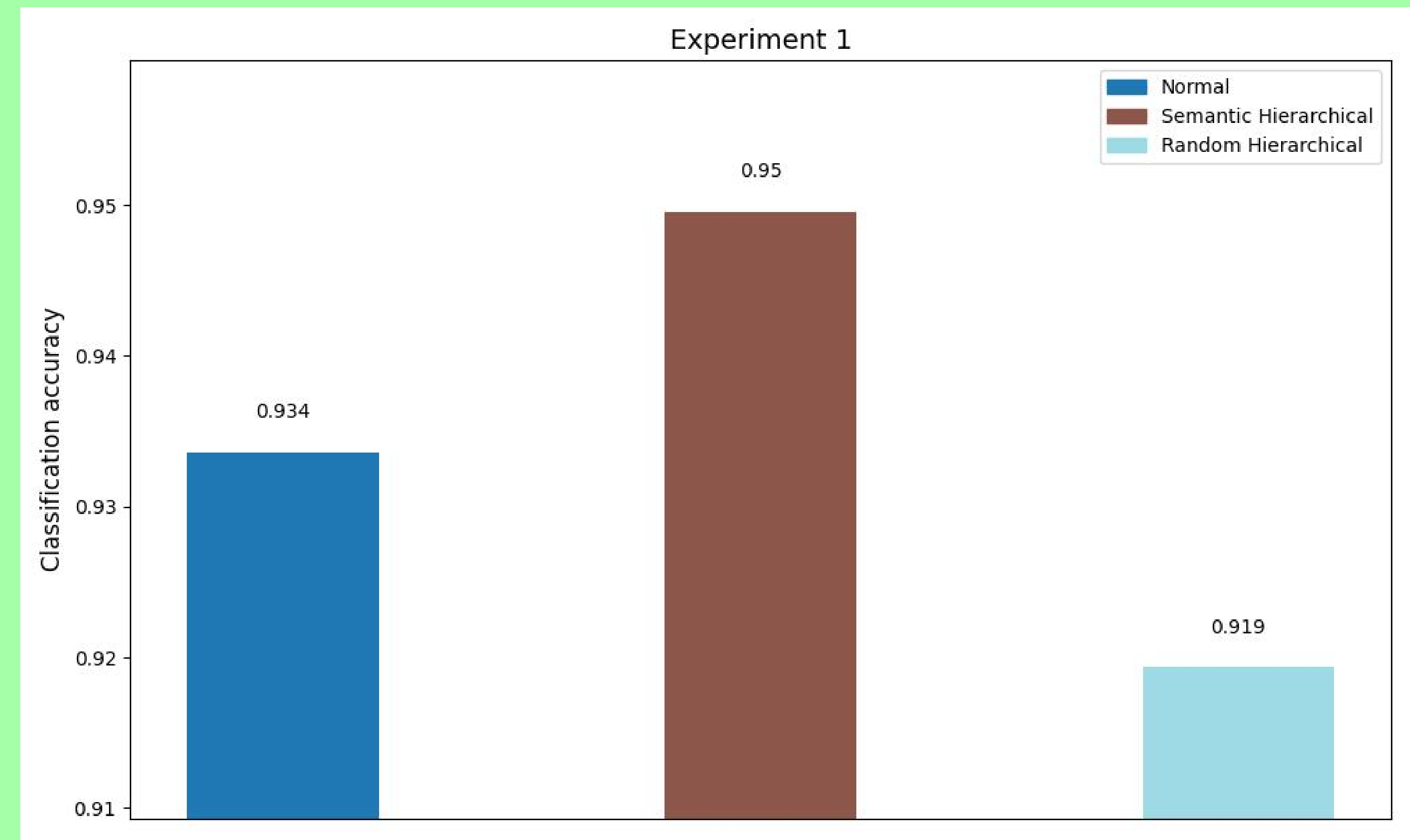


Figure 2: Class grouping for autonomous car object detectors. Example image for experiment 5. This image is manually labelled for the sake of the example. The actual experiment used slightly different classes.



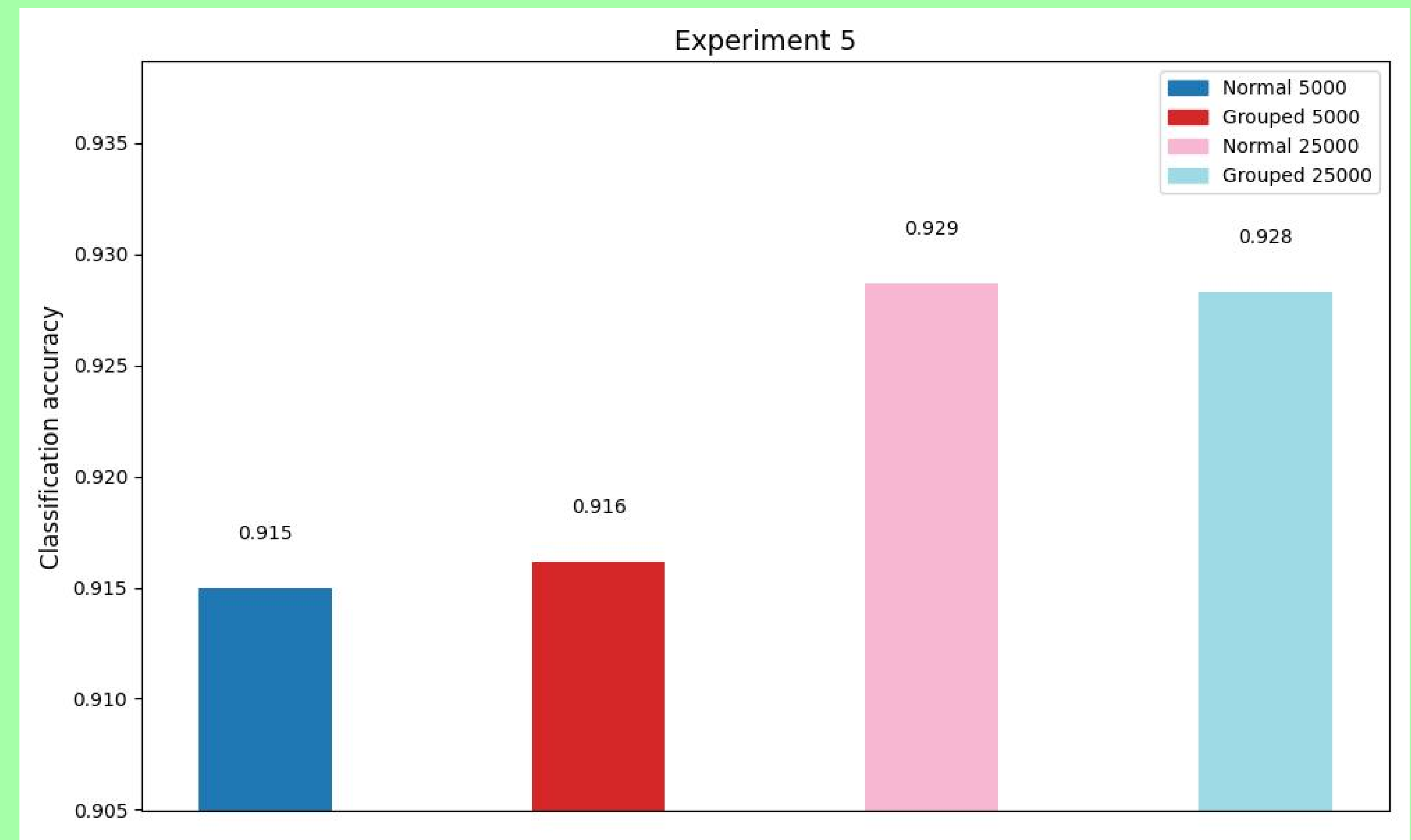
4. Results

Figure 3: Classification accuracy for normal, semantically grouped hierarchical and randomly grouped hierarchical model on the Pascal VOC 2012 dataset. This experiment was conducted to find out how much the grouping strategy matters and if it can outperform the base model.



- A hierarchical tree with semantically grouped classes performs better than a model trained on all base classes.
- Grouping strategies matter because the hierarchy with randomly grouped classes performed worse than the baseline.
- When grouped well, classification accuracy can be increased without extra labelling effort.

Figure 4: Classification accuracy for predicting grouped classes for a normal model trained on all base classes and a model trained on grouped classes for 5000 and for 25000 iterations on a dataset for autonomous cars. This experiment was conducted to find out if grouping classes can be used in practical applications to reduce labelling effort.



- When predicting grouped classes the model that was trained on grouped classes performs just as good as the model that was trained on the base classes. This shows that labelling effort can be reduced by grouping classes.
- Labelling effort can be reduced because there is no accuracy drop when comparing training on base or grouped classes.

5. Limitations

- Models were trained from pre-trained weights, not from scratch.
- Hierarchical structures were not optimized for training speed.
- Results were not aggregated from multiple instances of the same experiment but were verified for reproducibility.

6. Conclusion

- Hierarchical structures with class grouping improves model accuracy and reduces labelling effort.
- Semantic grouping is more effective than random grouping.
- Labelling effort can often be reduced when applications take actions based on classes predicted by object detectors.
- These results highlight the potential of hierarchical class grouping to improve object detection, leading to more efficient and accurate models in the future