Improving Vehicle Identification Through Advanced Fine-Grained Vehicle Classification

Gabriel E. Lima[1], Rayson Laroca[2], Eduardo Santos[1,3], Eduil Nascimento Jr.[3], and David Menotti[1]

[1]Federal University of Paraná

[2]Pontifical Catholic University of Paraná

[3]Paraná Military Police

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Summary

Introduction

Scope: vehicle identification.

Approach: integrating Automatic License Plate Recognition (ALPR) with Fine-Grained Vehicle Classification (FGVC).

Work in progress: enhance vehicle type classification through *superclass methods* and *selective prediction*.

Data preparation

Original data: RodoSol-ALPR dataset.

Figure: Samples from the RodoSol-ALPR dataset.

Data preparation: I) preprocessing; II) image selection; and III) annotations.

Vehicle-Type: 17,393 images categorized into eleven classes.

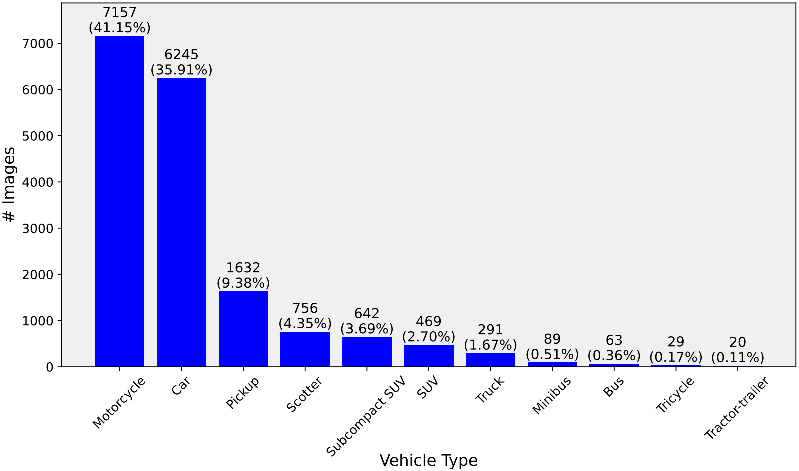

Figure: Distribution of vehicle types in the *Vehicle-Type* dataset.

Vehicle-Type: 17,393 images categorized into eleven classes.

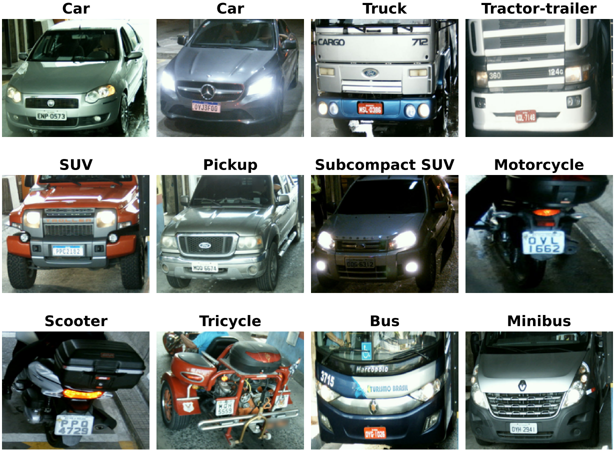

Figure: Examples from the *Vehicle-Type* dataset, obtained after applying the data preparation process on the RodoSol-ALPR dataset.

Experiments and Results

Baseline experiment: evaluate four deep learning models for vehicle type classification.

Methodology:

- *Models;*
- *Split;*
- *Data augmentation;*
- *Training protocols;*
- *Evaluation metrics.*

Additional experiments: (online) superclass; selective prediction.

Baseline experiment

Table: Global metrics on *Vehicle-Type* dataset (averaged over five runs). Protocol *(p2)* incorporates oversampling of minority classes, whereas *(p1)* does not.

Protocol	Model	Top-1	Top-2	Precision	Recall	F1
(p1)	ViT b16	**65.9**%	**88.1**%	**75.3**%	**65.9**%	**69.1**%
	ResNet 34	58.2%	80.4%	76.6%	58.2%	64.0%
	EfficientNetV2	50.6%	77.2%	69.2%	50.6%	56.1%
	MobileNetV3	61.7%	78.8%	73.5%	61.7%	65.5%
(p2)	ViT b16	**78.2**%	**92.0**%	**65.9**%	**78.2**%	**70.2**%
	ResNet 34	74.7%	89.4%	53.1%	74.7%	58.0%
	EfficientNetV2	73.7%	87.7%	50.1%	73.7%	55.8%
	MobileNetV3	70.3%	86.6%	51.5%	70.3%	57.1%

Experiments and partial results

Superclass and online superclass

Table: Mapping of original classes to superclasses.

Original Class	Superclass	Images
Motorcycle Scooter Tricycle	Motorcycle	7,942
Car	Car	6,245
Pick-up SUV Subcompact SUV	SUV	2,743
Tractor-trailer Truck	Truck	311
Bus Minibus	Bus	152

Table: Global accuracies using superclass and online superclass (averaged over five runs).

Method	Top-1	Top-2
Baseline	78.2%	92.0%
Superclass	87.8%	**98.1**%
Online Superclass	**88.0**%	96.7%

Selective prediction

Table: Global accuracies and rejection rates using Softmax Response Rejection method (averaged over five runs).

Minimum Confidence	Rejected Images	Correct Predictions Incorrectly Rejected	Top-1	Top-2
0.1	0 / 0.0%	0 / 0.0%	78.2%	92.0%
0.2	0 / 0.0%	0 / 0.0%	78.2%	92.0%
0.3	7 / 0.4%	2 / 0.1%	78.5%	92.4%
0.4	71 / 4.1%	28 / 1.6%	80.5%	94.0%
0.5	192 / 11.0%	92 / 5.3%	83.4%	95.0%
0.6	348 / 20.0%	192 / 11.0%	86.9%	95.6%
0.7	503 / 28.9%	308 / 17.7%	86.1%	92.3%
0.8	692 / 39.8%	472 / 27.4%	86.9%	92.9%
0.9	968 / 55.7%	730 / 42.0%	85.5%	90.3%

Selective prediction and online superclass

Table: Global accuracies and rejection rates using Softmax Response Rejection and online superclass (averaged over five runs).

Minimum confidence	Rejected Images	Correct Predictions Incorrectly Rejected	Top-1	Top-2
0.1	0 / 0.0%	0 / 0.0%	88.0%	96.7%
0.2	0 / 0.0%	0 / 0.0%	88.0%	96.7%
0.3	7 / 0.4%	4 / 0.2%	88.4%	97.1%
0.4	71 / 4.1%	45 / 2.6%	90.1%	98.3%
0.5	192 / 11.0%	129 / 7.4%	91.3%	98.7%
0.6	348 / 20.0%	260 / 15.0%	92.9%	98.9%
0.7	503 / 28.9%	399 / 22.9%	93.4%	99.1%
0.8	692 / 39.8%	580 / 33.4%	93.6%	99.2%
0.9	968 / 55.7%	850 / 48.9%	94.3%	99.3%

Conclusions

Remarks: both selective prediction and superclass methods can improve overall vehicle type classification accuracy.

Future directions: refine the studied methods; develop a combined ALPR and FGVC system.

Acknowledgments

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