

Contents

Contents	XV
1 Introduction	1
2 Fundamentals	5
2.1 Automotive Radar	5
2.1.1 Range and Doppler Extraction	6
2.1.2 Filtering Out Detections	8
2.1.3 Angle Estimation	9
2.2 Machine Learning	11
2.2.1 Deep Neural Networks	12
2.2.2 Maximum Likelihood Estimation	14
2.2.3 Loss Functions	15
2.2.4 Gradient Descent	16
2.2.5 Deep Learning Algorithms	18
2.2.6 Evaluation Metrics	23
3 Vanilla Model	25
4 Dataset	29
4.1 Ground Truth on Grid Dynamics	30
4.2 Ground Truth on Grid Segmentation	32
5 Doppler Disambiguation	35
5.1 Introduction	35
5.2 Contribution	39
5.3 Discrimination of Measurements	40
5.4 Preprocessing	42
5.5 Vanilla Radial Velocity Measurements	43
5.6 Enhanced Estimation of Radial Velocities	46
5.6.1 Model Adaptations	46
5.6.2 Radial Velocity Estimation as Regression	46
5.6.3 Disambiguating Radial Velocity Measurements	47
5.6.4 Ablation Studies	58
6 Estimation of Velocities by Incorporating Radial Velocity Measurements	61
6.1 Introduction	61
6.2 Contribution	63
6.3 Related Work	64

6.4	Model Adaptations	65
6.5	Velocity Prediction using Vanilla Convolutional Neural Networks	66
6.6	Integrating Radial Velocity Measurements	67
6.7	Mutual Interference between Radial and Tangential Velocity Predictions	80
6.8	Composition of Disambiguated Measurements and Tangential Velocities	83
7	Exploitation of Spatio-Temporal Correlations for Environment Perception	87
7.1	Introduction	87
7.2	Contribution	89
7.3	Grid Segmentation	90
7.3.1	Related Work	90
7.3.2	Derivation of a Baseline Model	91
7.3.3	Baseline Results	92
7.4	Defining a Shared Model for Velocity Estimation and Grid Segmentation	94
7.5	Enhanced Exploitation of Motion Patterns within Sequential Sensor Data	95
7.5.1	Study on the Contribution of Doppler Measurements vs. the Exploitation of Spatio-Temporal Patterns for Velocity Prediction	95
7.5.2	Related Work	100
7.5.3	Enhanced Methods to Increase Maximum Resolvable Velocities	109
7.5.4	Context Aware Recombination of Multi Scale Spatio-Temporal Features	117
7.5.5	Tracking Object Embeddings with Attention Mechanisms	128
8	Outlook	143
A	Appendix	147
A.1	Ego Location Compensation	147
A.2	Grid Segmentation Ground Truth Plots	150
A.3	Supplementary Material for Doppler Disambiguation	152
A.4	Supplementary Material for Velocity Decomposition	158
	Bibliography	164