

# Control of freeway traffic flow

S.A. Smulders

# Contents

1. Introduction	3
2. Modelling of Freeway Traffic Flow	11
2.1. Introduction	11
2.2. State equations	14
2.3. Observation equations	19
3. Simulation of Freeway Traffic Flow	25
3.1. Introduction	25
3.2. Stationary traffic	27
3.3. Unstable traffic	29
3.4. Congestion	32
3.5. Summary	38
4. Analysis of Freeway Data	41
4.1. Selection of periods of stationary traffic	41
4.2. Density estimation	45
4.3. Estimation of speed probability density and equilibrium speed	49
5. Filtering of Freeway Traffic Flow	57
5.1. Derivation of an approximate filter	57
5.2. Analysis of the filter	63

5.2.1. Detectability and stabilizability	63
5.2.2. Asymptotic error covariance	67
5.2.3. Speed information and estimator accuracy	71
5.3. Application of the filter	74
5.3.1. Performance criteria	74
5.3.2. Results with simulated data	78
5.3.3. Sensitivity tests	83
5.3.4. Validation	93
5.4. Conclusions	99
6. Control of Freeway Traffic Flow	101
6.1. Homogenizing control	102
6.2. Traffic models and stability	107
6.2.1. A one-dimensional model: traffic density	107
6.2.2. A two-dimensional model: density and speed	114
6.3. Control policy design	120
6.3.1. Introduction	120
6.3.2. Control based on traffic density	124
6.3.3. Finite horizon and discounting	129
6.3.4. Hysteresis control	133
6.3.5. Control based on both traffic density and mean speed	138
6.4. Conclusions	141
7. Conclusions	144
Appendix: Counting Processes and Martingales	147
References	151