YAW RATE AND SIDESLIP CONTROL USING H-INFINITY-PID CONTROLLER DURING AUTOMATED LANE CHANGE MANOEUVER

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by

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LIST OF ABBREVIATIONS

ABS	Anti-lock Braking System
ADAS	Advanced Driver Assistance System
ADB	Adaptive Driving Beam
AV	Autonomous Vehicle
BSM	Blind Spot Monitor
BO	Butterfly Optimisation
BP	Back-Propagation
CAS	Collision Avoidance System
CL	Closed-Loop
D	Derivative
DLC	Double-Lane-Change
DOF	Degree-of-Freedom
DYC	Direct Yaw Control
ESC	Electronic Stability Control
FWS	Front-Wheel-Steering
GPS	Global Positioning System
I	Intergral
ISO	International Organization for Standardization
I/O	Input and Output

LC	Lane Change
LDWS	Lane Departure Warning System
LHP	Left-Half-Plane
LHT	Left-Hand-Traffic
LiDAR	Light Detection and Ranging
LKA	Lane Keeping Assist
LPV	Linear Parameter Varying
MPC	Model Predictive Control
NCSA	National Center for Statistics and Analysis
NHTSA	National Highway Transportation Safety Administration
NN	Neural Network
Z-N	Ziegler-Nichols
OL	Open-Loop
P	Proportional
PI	Proportional-Intergral
PID	Proportional-Intergral-Derivative
PSD	Passing Sight Distance
RWD	Rear-Wheel-Drive
R-H	Routh-Hurwitz
SAE	Society of Automotive Engineering
SISO	single-input-single-output

SITO	single-input-two-output
SMC	Sliding Mode Control
SSD	Stopping Sight Distance
SWA	steering wheel angle
TISO	two-input-single-output
2D	Two Dimension

LIST OF SYMBOLS

a_y	Lateral acceleration
α	Tire slip angle
α_f	Tire slip angle of front wheel
α_r	Tire slip angle of rear wheel
θ_{Vy}	Angle of lateral velocity vector
β	Sideslip angle
$\dot{\beta}$	Sideslip angle rate
C_{α_f}	Cornering stiffness of front wheel
C_{α_r}	Cornering stiffness of rear wheel
$C_{\alpha_{f_{right}}}$	Cornering stiffness of front-ringht wheel
$C_{\alpha_{f_{left}}}$	Cornering stiffness of front-left wheel
δ	Steering wheel angle
δ_r	Rear wheel angle
δ_f	Front wheel angle
F_y	Lateral force
F_{yf}	Lateral force at front tire
F_{yr}	Lateral force at rear tire
$G(s)$	Plant transfer function
g_m	Gain margin

γ	Vehicle heading angle
γ_{H_∞}	Gamma in H_∞ analysis
K	Gain
K_p	Proportional gain
K_i	Integral gain
K_d	Differential gain
K_u	Critical gain
H_∞	H-infinity
H_2	H-two
I_z	Yaw moment of inertia
l_f	Distance from c.g. to front axle
l_r	Distance from rear axle to c.g.
M_z	Yaw moment inertia
m	Vehicle mass in kilogram
ω	Frequency
ϕ_m	Phase margin
T_u	Critical time
θ	Angle in radians
V_x	Longitudinal velocity or vehicle speed
V_y	Lateral velocity
$\dot{y}$	Lateral velocity at c.g. of vehicle

W	Vehicle weight in Newton
ψ	Yaw angle
$\dot{\psi}$	Yaw rate

KAWALAN KADAR REWANG DAN GELINCIR SISI MENGGUNAKAN PENDEKATAN PENGAWAL H-INFINITY-PID KETIKA PEMANDUAN PENUKARAN LORONG AUTOMATIK

ABSTRAK

Pengawal PID klasik digunakan dengan meluas dalam aplikasi sistem kawalan industri. Walaupun struktur sistem pengawal PID senang difahami dan ringkas, didapati bahawa untuk melaras parameter dan kadar pengawalnya adalah sukar, terutama bagi sistem kawalan kenderaan yang terbukti lebih kompleks dan memakan masa. Kajian ini bertujuan untuk mencadangkan algoritma pelarasan PID yang mudah dan menyelidik potensi penggunaan sintesis H_∞ dalam mengoptimumkan kadar pengawalan PID semasa pemanduan penukaran lorong automatik menggunakan anggaran sudut stereng model pemandu pada kelajuan tetap 80 km/j. Dua algoritma pelarasan telah dicadangkan; Pertama, menggunakan nilai K_pK_i dari sempadan lokus yang stabil bersama kaedah pelarasan Ziegler-Nichols (Z-N); Kedua, versi lanjutan dari algoritma pertama menggunakan kaedah hibrid H_∞ dan Chein. Dengan menggunakan model kenderaan sisi satu-masukan-dua-keluaran (SITO) kawalan-stereng-hadapan (FWS), kadar rewang, ψ dan gelinciran sisi, β, kedua-duanya dikawal menggunakan dua konfigurasi PID; Satu-PID dan Dua-PID. Perbandingan prestasi dilakukan antara PID yang dilaraskan secara automatik menggunakan MATLAB dan PID yang dilaraskan menggunakan kaedah yang dicadangkan. Pengawal H_∞PID menunjukkan prestasi yang lebih baik berbanding PID-MATLAB, terutamanya bagi konfigurasi Satu-PID yang menghasilkan hanya 1.71 % ralat pada nilai akhir anjakan sisi. Ia mengurangkan kira-kira 0.58% ralat oleh pengawal Satu-PID tanpa sintesis H_∞. Namun, untuk konfigurasi Dua-PID, ia hanya menghasilkan 55% keluaran jejak rujukan. Kesimpulannya, pe-

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