

INTISARI

PEMODELAN WAKTU HIJAU ALAT PEMBERI ISYARAT LALU LINTAS (APILL) MENGGUNAKAN SISTEM INFERENSI FUZZY MAMDANI DAN SUGENO

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Kemacetan pada persimpangan bersinyal masih menjadi permasalahan utama di kawasan perkotaan, terutama akibat sistem pengendalian sinyal yang tidak mampu menyesuaikan perubahan volume lalu lintas. Di Indonesia, pengaturan APILL umumnya masih menggunakan metode *fixed time* berbasis MKJI/PKJI yang bersifat statis dan kurang responsif terhadap kondisi dinamis, sehingga sering meningkatkan tundaan dan panjang antrian. Penelitian ini bertujuan mengimplementasikan dan membandingkan sistem inferensi fuzzy Mamdani dan Sugeno dalam pengaturan waktu hijau APILL serta mengevaluasi kinerjanya terhadap metode *fixed time* berdasarkan PKJI 2023.

Data survei diperoleh dari dua simpang di Kota Surakarta, yaitu Simpang 3 Gilingan dan Simpang 4 Pasar Kembang, yang memiliki karakteristik arus dan geometri berbeda. Data lalu lintas dikonversi ke satuan SMP/jam untuk perhitungan kapasitas simpang dan ke SMP/siklus sebagai input sistem fuzzy. Pada setiap pergantian fase sinyal, sistem fuzzy menentukan waktu hijau untuk fase yang sedang aktif berdasarkan kondisi arus lalu lintas, kemudian diterapkan secara bergantian hingga seluruh fase dalam satu siklus selesai dijalankan. Kinerja sistem dievaluasi menggunakan parameter PKJI 2023, yaitu panjang antrian (P_A), tundaan rata-rata simpang (T_I), dan tingkat pelayanan (LoS).

Hasil penelitian menunjukkan bahwa sistem fuzzy dapat meningkatkan kinerja simpang secara signifikan dibandingkan *fixed time*. Metode Mamdani menurunkan panjang antrian sebesar 19–84% dan tundaan sebesar 15–92%, sedangkan metode Sugeno menurunkan panjang antrian sebesar 15–83% dan tundaan sebesar 13–91%. Selain itu, distribusi LoS juga mengalami perbaikan dengan berkurangnya kejadian LoS E–F dan meningkatnya LoS C–D. Secara keseluruhan, metode fuzzy Mamdani menunjukkan kinerja yang paling konsisten dan stabil dalam merespons variasi arus lalu lintas, sehingga dinilai paling efektif sebagai alternatif pengendalian APILL dibandingkan metode *fixed time*.

Kata Kunci: APILL, Logika Fuzzy, Mamdani, Sugeno, PKJI 2023

ABSTRACT

TRAFFIC SIGNAL GREEN TIME MODELING USING MAMDANI AND SUGENO FUZZY INFERENCE SYSTEMS

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Traffic congestion at signalized intersections remains a major problem in urban areas, particularly when signal control systems are unable to adapt to changes in traffic volume. In Indonesia, traffic signal control (APILL) is generally still based on fixed-time methods based on MKJI/PKJI, which are static and less responsive to dynamic traffic conditions, often resulting in increased delay and queue length. This study aims to implement and compare two fuzzy inference systems, namely Mamdani and Sugeno, for APILL green time control and to evaluate their performance against the fixed-time method using PKJI 2023 parameters.

Traffic survey data were collected from two intersections in Surakarta City, namely Simpang 3 Gilingan and Simpang 4 Pasar Kembang, which have different traffic flow characteristics and geometric conditions. Traffic data were converted into passenger car units per hour (PCU/hour) for intersection capacity analysis and into passenger car units per cycle (PCU/cycle) as inputs for the fuzzy system. At each signal phase change, the fuzzy system determines the green time for the currently active phase based on traffic conditions, which is then applied sequentially until all phases within a signal cycle are completed. System performance was evaluated using PKJI 2023 parameters, namely queue length (P_A), average intersection delay (T_I), and level of service (LoS).

The results shows that fuzzy-based control significantly improves intersection performance compared to the fixed-time method. The Mamdani method reduces queue length by 19–84% and delay by 15–92%, while the Sugeno method reduces queue length by 15–83% and delay by 13–91% under various traffic conditions. In addition, the LoS distribution improves, with a notable decrease in E–F categories and an increase in C–D. Overall, the Mamdani fuzzy method demonstrates the most consistent and stable performance in responding to traffic flow variations and is therefore considered the most effective alternative for APILL control compared to the fixed-time method.

Keywords: Traffic Signal Control, APILL, Fuzzy Logic, Mamdani, Sugeno, PKJI 2023