# ABSTRAK

**Nama** : **Romi Patria Sanjaya**
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**Judul** : **Algoritma Genetika Hibrida untuk *Multiple Traveling Salesman Problem* menggunakan Pendekatan *Min-Max***

Efisiensi perencanaan rute menjadi tantangan utama dalam berbagai sektor seperti logistik, distribusi barang, dan koordinasi multi-agen. Salah satu model matematis yang relevan untuk merepresentasikan permasalahan tersebut adalah *Multiple Traveling Salesman Problem* (mTSP). Sebagai permasalahan NP-hard, mTSP sulit diselesaikan secara eksak pada skala besar, sehingga pendekatan metaheuristik menjadi sangat diperlukan.

Penelitian ini mengusulkan Algoritma Genetika Hibrida (HGA) yang mengintegrasikan Algoritma Genetika, pencarian lokal (*Local Search*), dan K-Medoids (PAM) dalam satu kerangka terintegrasi. Populasi awal dibangkitkan menggunakan heuristik *Nearest Neighbor* dengan randomisasi, pembagian rute antar salesman dilakukan menggunakan K-Medoids (PAM), dan evaluasi fitness mempertimbangkan jarak maksimum serta keragaman populasi berbasis *Hamming Distance*. Operator crossover yang digunakan adalah *Similar Tour Crossover* (STX), didukung mekanisme Edukasi Kromosom dua lapis untuk perbaikan *inter-route* dan *intra-route*, serta mekanisme diversifikasi untuk menghindari solusi lokal. Algoritma diimplementasikan menggunakan Python pada Google Colab dengan dataset benchmark TSPLIB: eil51, berlin52, eil76, pr76, gr96, dan rat99.

Hasil eksperimen menunjukkan HGA yang diusulkan menghasilkan Gap sebesar 1,007 terhadap metode eksak CPLEX, artinya solusi rata-rata hanya 0,7% di atas solusi optimal, sekaligus mengungguli metode berbasis pembelajaran DAN dan ScheduleNet. Operator STX menghasilkan performa terbaik dibandingkan OX, PMX, dan STX-PMX dengan mean fitness 24.572,4. Edukasi Kromosom terbukti meningkatkan kualitas solusi secara signifikan, dan K-Medoids (PAM) menghasilkan pembagian beban rute yang seimbang antar salesman dengan CoV Salesman mayoritas di bawah 10%.

**Kata Kunci:** *Multiple Traveling Salesman Problem*, Algoritma Genetika Hibrida, *Min-Max*, *Similar Tour Crossover*, K-Medoids.

# ABSTRACT

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**Title** : **Hybrid Genetic Algorithm for Multiple Traveling Salesman Problem Using Min-Max Approach**

Route planning efficiency is a major challenge across various sectors such as logistics, goods distribution, and multi-agent coordination. One mathematical model relevant to representing this problem is the *Multiple Traveling Salesman Problem* (mTSP). As an NP-hard problem, mTSP is difficult to solve exactly at large scales, making metaheuristic approaches highly necessary.

This study proposes a Hybrid Genetic Algorithm (HGA) that integrates a Genetic Algorithm, Local Search, and K-Medoids (PAM) within a unified framework. The initial population is generated using a randomized Nearest Neighbor heuristic, route assignment among salesmen is performed using K-Medoids (PAM), and fitness evaluation considers both the maximum distance and population diversity based on Hamming Distance. The crossover operator used is *Similar Tour Crossover* (STX), supported by a two-layer Chromosome Education mechanism for inter-route and intra-route improvement, along with a diversification mechanism to avoid local optima. The algorithm is implemented in Python on Google Colab using TSPLIB benchmark datasets: eil51, berlin52, eil76, pr76, gr96, and rat99.

Experimental results show that the proposed HGA achieves a Gap of 1.007 against the exact method CPLEX, meaning the average solution is only 0.7% above the optimal solution, while outperforming learning-based methods DAN and ScheduleNet. The STX operator yields the best performance compared to OX, PMX, and STX-PMX with a mean fitness of 24,572.4. Chromosome Education is proven to significantly improve solution quality, and K-Medoids (PAM) produces a balanced route load distribution among salesmen with the majority of Salesman CoV below 10%.

**Keywords:** *Multiple Traveling Salesman Problem*, Hybrid Genetic Algorithm, *Min-Max*, *Similar Tour Crossover*, K-Medoids.