Highway intelligent traffic Management system

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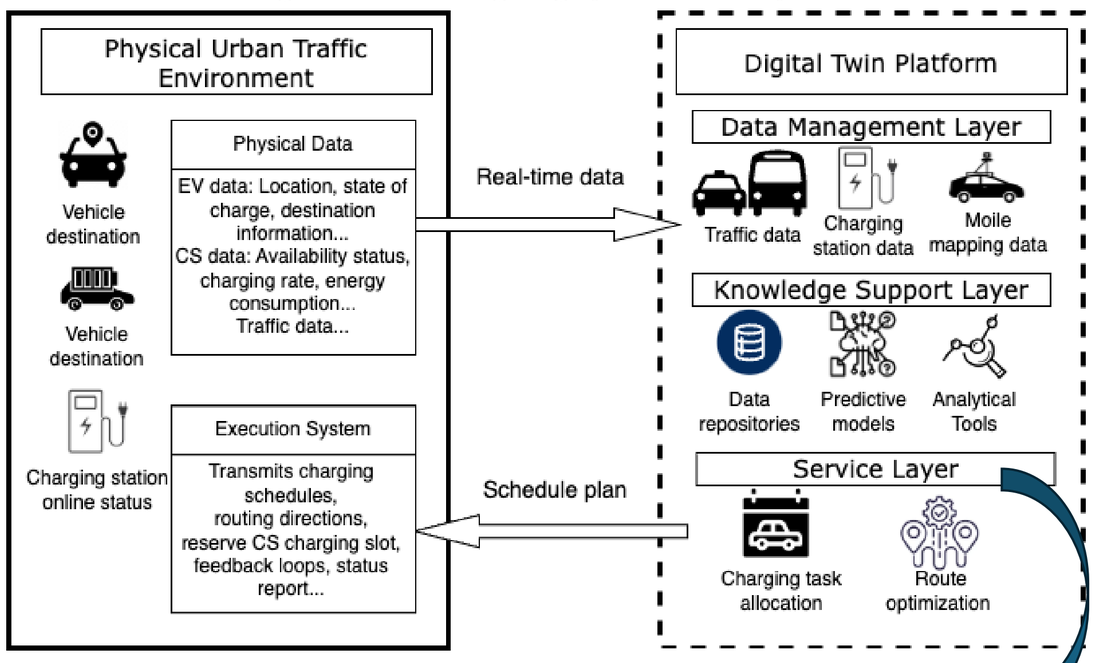
Background & Motivation

- **Traffic Congestion**: increasing congestion leads to longer travel time, fuel waste and pollution.
- **Electric Vehicle Integration**: the rise in EVs requires efficient charging and routing solutions.
- **Intelligent Transport systems (ITS)**: Intelligent systems can address urban mobility, congestion, and environmental goals.

Research Goals:

- **Multi-agent Traffic Management System**: develop a system that considering EVs to reduce congestion and optimize routing and charging.
- **Implement Adaptive Traffic Control**: Design algorithms that adjust to diverse conditions, like road closures and seasonal maintenance.
- **Integrate V2G for Energy Efficiency**: Enable V2G communication to optimize EV charging and energy distribution.

System framework of the Digital Twin-based Electric Vehicle Routing and Charging (DT-EVRC)



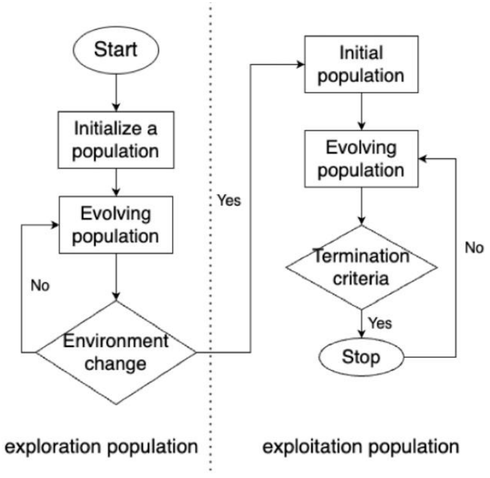


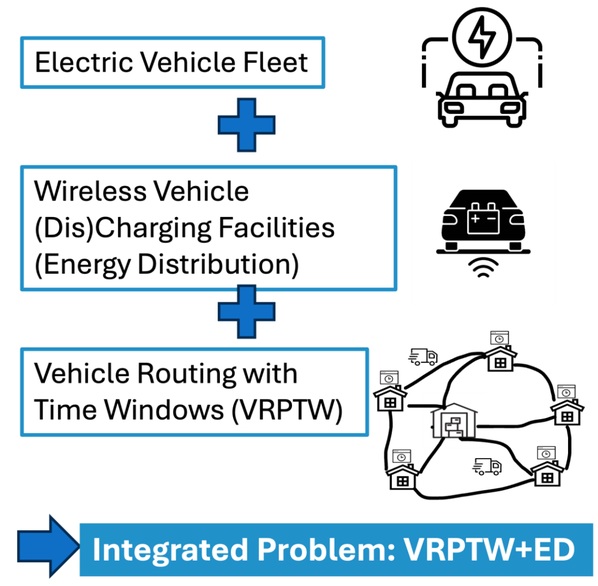
Fig. 2: Flowchart of the proposed DPEA for the dynamic traffic-aware EVs charging routing problem

Algorithm 2 Dual-Population Evolutionary Algorithm (DPEA)

1: Initialize exploration population P_{explore} using Algorithm 1;
2: Evaluate initial populations using fitness functions F_1 and F_2;
3: Set generation counter $G \leftarrow 0$
4: **while** stopping criteria is not satisfied **do**
5: *{Exploration Population Evolution}*
6: **for** each individual x in P_{explore} **do**
7: Update the location of all EVs according to the on-time information provide by DT;
8: Generate a new individual x' with mutation, crossover and repair;
9: **if** $H(P_{\text{explore}} \backslash x \cup x') > H(P_{\text{explore}})$ **then**
$x \leftarrow x'$;
10: **end if**
11: **end for**
12: **if** DT system detected environment change **then**
13: *{Exploitation Population Evolution}*
14: Update P_{exploit} with top N solutions from P_{explore};
15: Apply local search and repair to P_{exploit} to refine solutions;
16: Evaluate fitness values of new solutions in P_{exploit};
17: Update P_{exploit} based on non-dominated sorting ;
18: *{Selection of Best Solution}*
19: Select best solution x^* from P_{exploit} using TOPSIS;
20: Apply x^* in real-world;
21: Update P_{explore} according to x^* ;
22: **end if**
23: **end while**

Efficient Electric Vehicle Routing and Energy Allocation Through Multi-Objective Optimization

- The results show that integrating VRPTW and ED enhances operational efficiency, vehicle utilization, and cost-effectiveness by optimizing routing and energy constraints.



F1: total energy cost
F2: total energy transmit
Vs: number of used vehicles

Table 3: Performance Comparison between VRPTW-ED, VRPTW, ED and VRPTW&ED, the **best objective values** between VRPTW-ED and VRPTW&ED are highlight.

Instance	VRPTW-ED			VRPTW		ED			VRPTW + ED		
	F1	F2	Vs	F1	Vs	F1	F2	Vs	F1	F2	Vs
c1-5	**416.7**	**281.86**	40	168.77	39	436.5	178.31	5	605.27	178.31	44
c2-4	850.8	**222.80**	38	133.00	35	651.3	179.94	7	**784.30**	179.94	42
r2-4	636.9	**241.22**	25	74.46	25	412.8	174.72	6	**487.26**	174.72	31
rc1-2	**343.5**	**124.75**	27	76.08	24	346.8	115.03	3	422.88	115.03	27
rc2-4	**392.4**	**279.69**	31	177.95	34	289.2	202.42	5	467.15	202.42	39

- This research introduces DT-EVRC approach, combined with the Dual-Population Evolutionary Algorithm (DPEA), to optimize EV routing and charging in intelligent transportation systems.

Real-world case study:

Temporary traffic management

- Short-term Disruption Management: Prioritize real-time updates in the DT-EVRC system for temporary disruptions, directly communicating to drivers.
- Integration with Smartphone and In-Vehicle Displays: Provide dynamic guidance to promote adherence over static mapping apps.
- Driver Compliance Studies: Analyze driver adherence to DT-EVRC routes versus standard navigation apps.

Seasonal road management:

- Comprehensive Seasonal Management Strategies
- Emergency and Hazard Alerts
- Coordination with Local Road Services.

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