Bees and ETRVs: An unlikely match-up of the natural world and electric trackless rubber-tired vehicles

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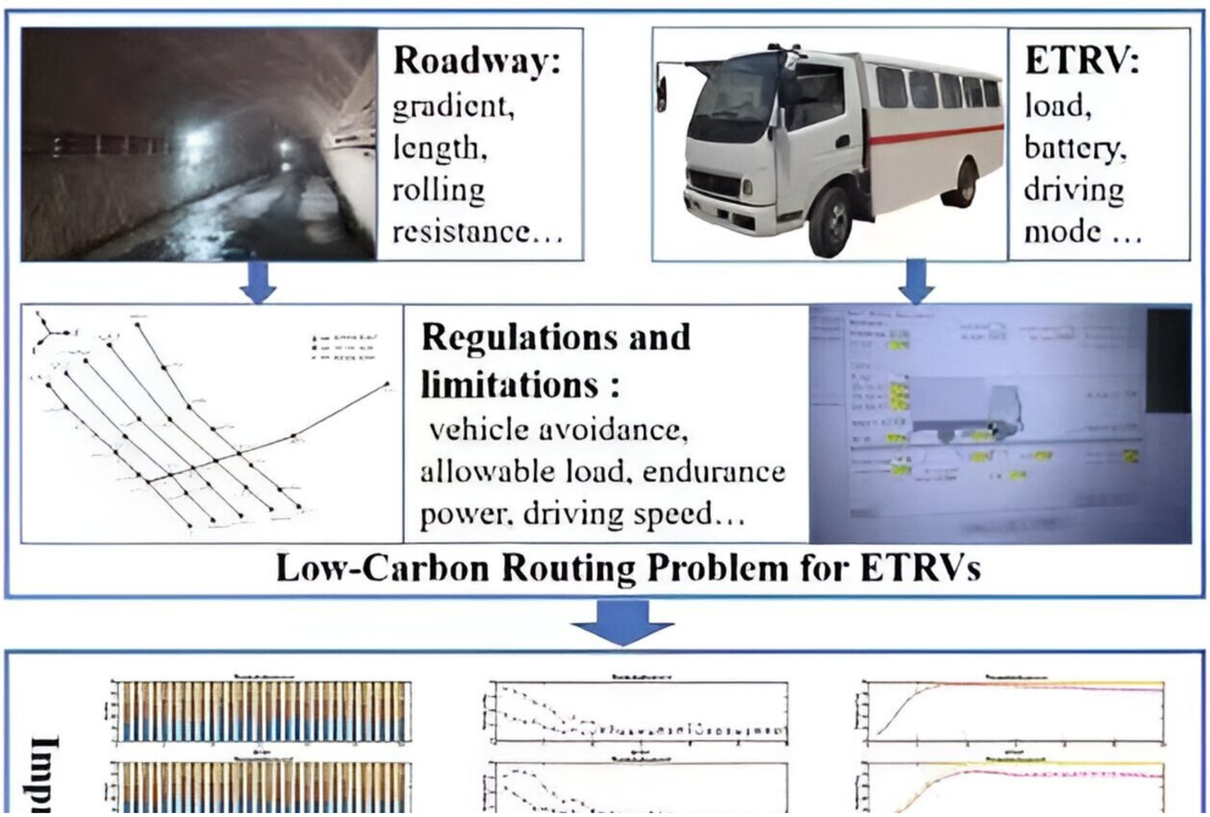

Low-carbon routing issues can be solved by using improved artificial bee colonies (IABC) to provide optimal routes to minimize energy consumption and other limitations that come with electric trackless rubber-tyred vehicles (ETRVs). Credit: Yinan Guo, China University of Mining and Technology (Beijing)

The natural world works off algorithms, so researchers thought to use one of the world's most industrious animals, the honeybee, as a basis for determining energy-efficient routes in electric trackless rubber-tired vehicles (ETRVs).

Bees are an effective, integral and orderly part of the animal kingdom, though learning to stop and smell the roses isn't the only thing we can borrow from the bees. The foraging behavior of honeybees might be a useful tool in figuring out the best, most energy-efficient routes for electric trackless rubber-tyred vehicles (ETRVs) which are a crucial piece of equipment for mining operations and transportation.

Limitations of ETRVs include excessive energy consumption, potential operational safety issues and a lack of control when considering load size, slope, and vehicle avoidance. Finding out the routes these vehicles can take by using an improved artificial bee colony (IABC) algorithm can minimize potential issues all while reducing the energy consumption of the vehicle.

This has positive implications not only economically and environmentally, but can also improve the overall safety and function of the vehicles for a smarter future of ETRVs.

Researchers published their results in *Complex System Modeling and Simulation*.

"The experimental results on four real-world instances indicate that improved artificial bee colony algorithm (IABC) outperforms other comparative algorithms and the special designs in its three phases effectively avoid premature convergence and speed up convergence," said Yinan Guo, researcher and author of the study.

IABC isn't the only algorithm tested in this study, though it did seem to be the most effective in setting up routes that are energy efficient. Other colony models researchers used to determine what route may be the most effective include particle swarm optimization, which utilizes the randomly selected (stochastic) social interactions of swarming agents to look for the best solution in a given space.

The other algorithms used are genetic algorithms, which employ the theory of "natural evolution" for problem-solving, and ant colony optimization which ideally will find the shortest path to a solution.

Parameters were set among all four algorithms used to ensure a fair comparison, including population size, the maximum number participating in a neighborhood search and weight. The artificial bee colony (and the other colony models) is tasked with searching for a food source. The best, least energetically costly route the artificial bees take is likely the best, least energetically costly option for the ETRVs, too.

Within the IABC there are three strategies: adaptive neighborhood search for employed bees (those who go to the food source and return to the hive and dance), adaptive selection probability for onlookers (those who evaluate nectar information via the dance of employed bees) and knowledge-driven initialization for scout bees (employed bees whose food source has been abandoned and searches for a new food source).

"IABC achieves the most competitive solution on all instances and is significantly better than its variants. This proves that three newly designed strategies are helpful to effectively enhance the algorithm performance," said Guo.

To solve the problem of electric vehicle routing, load size, slope, energy consumption, vehicle avoidance and driving state all need to be considered, and the adaptive neighborhood search strategy helps guide the bees to the more appropriate area. The onlookers adjust their selection of food sources based on quality and evolution efficiency, and the scouts help to improve convergence efficiency and the population diversity, producing better solutions for the population.

The implicit parallels among bees searching for the best route to reach their food and an ETRV taking the most energy-efficient route can be seen plainly when given the comparison. With the increasing number of service nodes, the search space is expanded dramatically, and the algorithms performance becomes worse. The most effective solution tops out at 15 service node stops, with a particular pattern between the nodes that should minimize carbon emissions and energy consumption.

Even though researchers have found promise in utilizing IABC to solve some of the issues with routing the ETRVs, future work involves scheduling heterogeneous TRVs with variable powers built-in to the vehicle. This will help to eliminate some of the problems related to energy consumption the IABC doesn't quite account for, such as the limited ability for cruising, speed adjustment and road conditions. These are complex issues to address with any algorithm, but the groundwork done using IABC might be enough for studies in the coming years.

More information: Yinan Guo et al, Low-Carbon Routing Based on Improved Artificial Bee Colony Algorithm for Electric Trackless Rubber-Tyred Vehicles, *Complex System Modeling and Simulation* (2023). DOI: 10.23919/CSMS.2023.0011

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