Strategic decisions for routing autonomous vehicles: When to reoptimise?

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Abstract: The Information-Collecting Vehicle Routing Problem is a new class of problems addressing how to efficiently collect information while navigating to multiple points of interest (POIs) in an uncertain environment. Autonomous vehicles, with inbuilt computers and sensors, are natural information-collecting agents, continually detecting new information in a dynamic environment. However, there is still a distinct lack of research on using autonomous vehicles as information-collecting agents to discover new POIs based on proximity, despite the growing body of literature for dynamically routing autonomous vehicles. To address this gap, we introduce the concept of *proximity-dependent nodes* and define a *detectibility radius* to the Dynamic Vehicle Routing Problem (DVRP). This DVRP variant will be relevant to any application in which autonomous vehicles visit known locations as well as detect and immediately address new POIs – e.g. finding victims in an emergency response after a natural disaster, or tracking down invasive species in agritech.

An important question when building a solution framework for the DVRP with proximity-dependent nodes is *when* to trigger a reoptimisation after detecting a new POI/node. There are two main trigger types: exogenous (external event triggers reoptimisation; e.g. detecting new POI) and endogenous (internal event triggers reoptimisation; e.g. arrived at current POI). There is no consensus in literature on which trigger type is more effective for the DVRP, and no known study comparing the two triggers on classical DVRP benchmarks.
In light of this, computational experiments were run comparing the exogenous and endogenous triggers on the Uchoa et. al. (2017) benchmarks for both the classical DVRP and the proximity-dependent variant. The benchmarks are split into three geographical distributions: clustered (C), random-clustered (RC), and random (R), and we run simulations at varying levels of dynamism (0.25, 0.5, 0.75). A linear model was applied to statistically compare trigger performance at minimising travel distance and maximising node detection.
The benchmark results revealed a statistically significant advantage ($p < 0.5$) in using the endogenous trigger over the exogenous trigger for almost all cases. However, the exogenous trigger can be advantageous for random node distributions (R) with lower dynamism (0.25) and lower detectibility.

Figure 1 shows the non-linear relationship between detectibility and node detection, indicating practitioners can estimate the sensor range required to ensure their autonomous vehicle detects an efficient proportion of POIs. These findings give clearer insight into how strategic decisions at the design level can significantly influence the performance of a DVRP solution framework. The practitioner should choose trigger type carefully after considering problem characteristics such as geographical distribution, degree of detectibility radius.

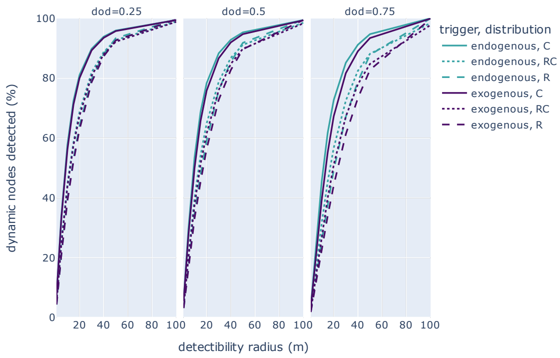

Figure 1. Detectibility radius vs node detection.

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