The orienteering problem with time-dependent stochastic travel times

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This research compares two solution methods for the orienteering problem (OP) with time-dependent stochastic travel times (TDS-OP). In Orienteering problems an optimal combination of vertices needs to be selected and the routing between the vertices needs to be optimized, due to the limited available time. In this particular version the travel time are both dynamic and stochastic and are therefore modelled as a function of distributions. This specific problem formulation allows us to tackle congestion related issues in routing problems that deal with high uncertainty.

To the best of our knowledge, time-dependency for the orienteering problem has only been discussed by Fomin & Lingas [3], Abbaspour & Samadzadegan [1], Garcia et al. [4], Li et al. [6], Li [5], Verbeeck et al. [7] and stochasticity has only been applied to the OP by Campbell et al. [2].

We mathematically define this problem and propose an evaluation function. Subsequently, two solution procedures are developed: the first solution method generates solutions to the (time-independent deterministic) OP using an iterated local search framework. The generated solutions are afterwards evaluated as TDS-OP solutions by the evaluation function. In the second method a problem instance is solved as a time-dependent orienteering problem by the ant colony optimisation approach developed by Verbeeck et al. [7]. For each arc in the network the time-dependent travel time corresponding to the 95% percentile of its travel time distribution is used. Afterwards these solutions are evaluated as TDS-OP solutions. A set of realistic problem instances was developed based on the realistic road network of Belgium, the Netherlands and Luxembourg, containing 425,479 vertices and 519,915 arcs with accurate 15 minute travel time distributions for each arc. Currently, both methods are being compared based on solution quality and computational performance.

[1] Abbaspour, A., & Samadzadegan, F. (2011). Time-dependent personal tour planning and scheduling in metropolises. *Expert Systems with Applications*, *38*, 12439–12452.

[2] Campbell, A., Gendreau, M., & Thomas, B. (2011). The orienteering problem with stochastic travel and service times. *Annals of Operations Research*, *186*, 61–81.

[3] Fomin, F., & Lingas, A. (2002). Approximation algorithms for time-dependent orienteering. *Information Processing Letters*, *83*, 57–62.

[4] Garcia, A., Vansteenwegen, P., Arbelaitz, O., Souffriau, W., & Linaza, M. (2013). Integrating Public Transportation in Personalised Electronic Tourist Guides. *Computers & Operations Research*, *40*, 758–774.

[5] Li, J. (2011). Model and algorithm for time-dependent team orienteering problem. In S. Lin, & X. Huang (Eds.), *Advanced Research on Computer Education, Simulation and Modeling* (pp. 1–7). Springer Berlin Heidelberg volume 175 of *Communications in Computer and Information Science*.

[6] Li, J., Wu, Q., Li, X., & Zhu, D. (2010). Study on the time-dependent orienteering problem. In *International Conference on E-Product E-Service and E-Entertainment (ICEEE)*.

[7] Verbeeck, C., Sörensen, K., Aghezzaf, E.-H., & Vansteenwegen, P. (2013). A fast solution method for the time-dependent orienteering problem. *European Journal of Operational Research*, *accepted for publication doi 10.1016/j.ejor.2013.11.038*.