# Towards an R Package for the Shortest Path Problem with Forbidden Paths

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## 1 Introduction

The *shortest path problem with forbidden paths* (SPPFP) is a variant of the original shortest path problem. Given a directed graph $G = (N, A)$, there is also a related set $F$ of known forbidden sub-paths in $G$. The problem is to find the shortest paths from a source to a destination node, with no paths in the solution contain forbidden sub-path.

SPPFP has been addressed in the academic literature, and different solutions have been proposed [1,2,3]. This problem has several lines of application in research, such as time windows networks, logistics, and more [4]. R is a free- software environment for statistical computing and graphics, and its potential depends on the packages contributed to the project by the community; however no R packages includes the SPPFP.

## 2 Functionality Implementation

Current proposals for solving the SPPFP transform the original directed graph $G$ into an equivalent graph $G^*$ which includes the forbidden sub-paths $F$. Then, regular *shortest path* algorithms are used on $G^*$ to find the shortest path. This approach has a number of advantages: a) in cases where $G$ and $F$ are not often modified, the graph has to be generated only once, and b) there are existing powerful tools, such as IGraph [5] and others, which provide functionalities for network analysis, but cannot handle the SPPFP variant. The latter is important, as currently anyone dealing with this problem is first forced to first code these algorithms.

The proposed package works with graphs $G$ formulated as data-frame of arcs written like $\{from, to\}$ pairs, with or without additional attributes. This is transformed to $G^*$ and returned in the same format. Hence, other libraries functionalities can be applied to the resulting graph.

Fig. 1 presents an example of an original graph, with forbidden paths $F = \{f_1(s,u,v,t), f_2(u,v,t,y)\}$, transformed with this package. The nodes belonging to $F$ paths are duplicated, and arcs are added or removed under different constraints.

The functions developed for the proposed package are grouped in two sets:

- Parsing Functions: $G^*$ always returns answers in terms of its nodes; then, `parse_vpath` translates the solution back to $G$, and `get_all_nodes` returns are the equivalents $N^*$ for a original $N$. As SPPFP algorithms work only with directed graphs, the function `direct_graph` converts a regular graph into a directed one.

- Transformation Functions: The package core includes two functions `modify_graph` to transform a digraph; one of them follows the logic proposed by Villeneuve and Desaulniers [3], and the other to Hsu et al. [6].

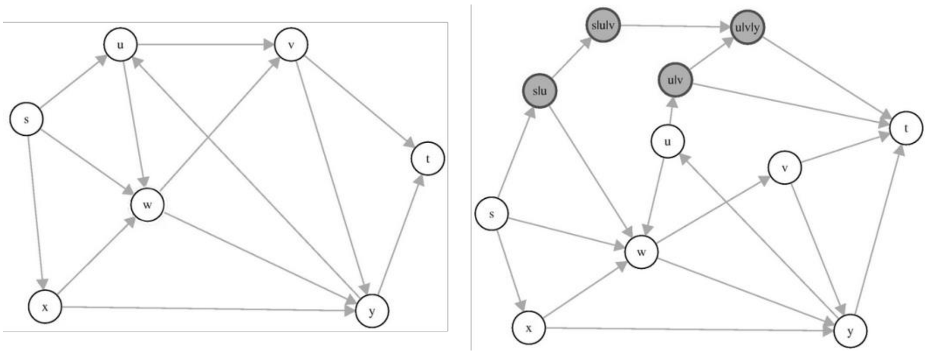

**Fig. 1.** Left: original graph $G$. Right: modified graph $G^*$. Displayed with IGraph.

## 3 Conclusions

This article presents an R package to provide functionalities to solve the SPPFP by transforming existing graphs, using different algorithms proposed in the academic literature. As the SPPFP has many applications, and because the use of R continues to increase due to the increased relevance of data science, a package like the proposed one could benefit many developers. As future work, other algorithms could be developed and included, to contemplate different situations regarding forbidden paths.

## 4 References

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