# Mixed-Integer Nonlinear Programming Models for the Close-Enough Traveling Salesman Problem

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## Overview

In this optimization problem we develop a model to find the minimum distance Hamiltonian cycle through a set of nodes where the tour must only get within a specified distance of each node in order to visit it. The model simultaneously determines the sequence of nodes in the cycle and the points at which the nodes are visited[1].

Two mixed-integer nonlinear programming (MINLP) formulations of this problem are presented. The first formulation is a nonconvex MINLP with a nonconvex objective function, a convex quadratic constraint corresponding to each node, a nonconvex quadratic constraint corresponding to each arc and integer linear constraints. The second formulation replaces the nonconvex constraints with convex constraints, adds variables to represent the $\Delta x$ values between nodes $i$ and $j$, and adds variables to represent the $\Delta y$ values between $i$ and $j$. This formulation is a MINLP with a convex objective function, the same linear and convex quadratic constraints as in the first model, and additional linear constraints.

We have not yet solved any large problems to optimality (even a small, enumerable problem failed to come close to LB = UB using BARON before running out of memory).

## References

[1] W. Mennell. *Heuristics for solving three routing problems: Close-Enough Traveling Salesman Problem, Close-Enough Vehicle Routing Problem, Sequence-Dependent Team Orienteering Problem.* PhD thesis, University of Maryland, College Park, 2009.