Artificial Landmark Placement for Mobile Robot Navigation

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The integration of robots into real world environments is a difficult problem. The problem of improving the performance of robots by autonomously adapting them to different tasks and environments has been extensively studied recently (see e.g. [1,2]). However, the problem is still far from being solved. Therefore, for many applications, it is preferable to use different adaptations of environments. In particular, artificial visual landmark navigation has been widely studied (see e.g. [3,4]). We consider the problem of artificial visual landmark placement for a low-cost mobile robot navigation. We assume that an instrumentation of the environment with artificial visual landmarks is used to improve the mobile robot performance. We use a humanoid robot for the placement of artificial visual landmarks. We need to minimize the path length of the humanoid robot.

We assume that the mobile robot must solve some task. To solve the task, the robot must visit the multiset of points $U = \{U_1, U_2, \ldots, U_n\}$ in the predetermined sequence $U_1, U_2, \ldots, U_n$. Let V be the set such that $V = \{V_i \mid V_i \in U\}$. Let $S = \{S_1, S_2, \ldots, S_k\} \subseteq U$ be the set of all points that must be equipped with artificial visual landmarks. Let G be the weighted complete graph with the set of vertices V and the weight function F. We assume that the robots have the same speed. It is assumed that the robots have arbitrary initial positions. Also, we assume that the robots do not stop after the start of movement. Let $t_M(S_i)$ be the time such that the mobile robot is located at S_i for the first time, $i \in \{1, 2, \ldots, k\}$. Let $t_H(S_i)$ be the time such that the humanoid robot is located at S_i, $i \in \{1, 2, \ldots, k\}$. Let A be the weighted complete graph with the set of vertices S and the weight function $F|_S$.

Artificial Visual Landmark Placement for Mobile Robot Navigation (LP):

Instance: *Weighted complete graphs G and A, the sequence $U_1, U_2, \ldots, U_n$.*

Task: *Find the shortest tour of S such that $t_M(S_i) \leq t_H(S_i)$, $i \in \{1, 2, \ldots, k\}$?*

The decision version of LP can be formulated as following.

LP_D:

Instance: *Weighted complete graphs G and A, the sequence $U_1, U_2, \ldots, U_n$, positive integer t.*

Task: *Is there a tour of S such that $t_M(S_i) \leq t_H(S_i) \leq t$, $i \in \{1, 2, \ldots, k\}$?*

Theorem 1. LP_D *is* **NP**-*complete.*

Theorem 2. LP *is* $\mathbf{FP}^{\mathbf{NP}}$-*complete.*

In view of intractability of LP, we propose an explicit reduction from LP_D to the satisfiability problem.

References

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