

1 Problem 5
2 Consider the genetic algorithm trajectory tracking for manipulators, and answer the
3 following questions:
4 References: Tarokh, M. & Zhang, X. J Intell Robot Syst (2014) 74: 697.
5 <https://doi.org/10.1007/s10846-013-9860-4>
6 a. What are crossover and mutation in the context of manipulator trajectory tracking?
7
8 Given an artificial chromosome of L bits where each bit maps to a feature in the
9 problem domain, the crossover operator exchanges parts of two randomly selected
10 chromosomes, producing two distinct offsprings. The mutation operator changes bits in
11 the chromosome in random locations in the chromosome.
12
13 In the context of manipulator trajectory tracking, chromosomes represent joint
14 angle vectors and individual angles represent genes in the chromosome.
15 b. What are the optimization and constraints, and how are they treated/taken care of?
16
17 The optimal real-time trajectory tracking problem can be stated as follows: Given
18 the desired workspace posture trajectory $u(t)$ and the start configuration described
19 by the joint angle vector s , compute the next joint angle vectors $((j + 1) t) \equiv (j +$
20 $1), j = 0, 1, \dots, m - 1$ such that:
21 (a) Constraint (1) is satisfied.
22 (b) The optimization objective (2) is achieved.
23 (c) The position and orientation tracking errors ϵ_p and ϵ_o are within the
24 acceptable ranges.
25 (d) The joint velocities and accelerations are within physically acceptable
26 ranges.
27 (e) The time required to compute the next joint angle vector $(j + 1)$ is no more
28 than $t = T/m$ to enable real time operation.
29 c. What is the definition of fitness function in trajectory tracking?
30
31 The definition for the fitness function in trajectory tracking is based off of the
32 amount of error in the current generation. Specifically the fitness level is computed
33 by comparing the end-effector's trajectory to the actual desired trajectory.
34 d. Genetic algorithm solutions are generally time consuming. How are they used to
35 achieve real-time in trajectory tracking?
36
37 "In order to achieve real time tracking, special provisions are made so that only
38 an appropriate small region in the joint space is searched. The tracking problem is
39 solved at the position level rather than the velocity level. As such the proposed
40 method does not use the manipulator Jacobian inverse or pseudo-inverse matrix and is
shown to be free from problems such as excessive joint velocities due to
singularities." (Tarikh, Zang, pg. 1)
e. List three features of genetic algorithm for trajectory tracking that are not
achievable using the Jacobian method?
1. Less prone to excessive joint velocities due to singularities
2. any simple or complex constraint or optimization objective can be specified in
the genetic algorithm formulation
3. Real-time trajectory functions (very fast)