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Abstract

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1 Introduction

1. - What are redundant robots
   - What is the use of redundancy
   - examples of applications of redundant robots
   - what is the downside?
   - what is called redundancy resolution. Say that the displacement of tip is specified and the co-ordinates(or the joint angles) of the subsequent links should be found out.
2. - State that the major advantage of red. robots is obstacle avoidance
   - What is the first redundacy resolution scheme? Did it avoid obstacles?
   - How is obstacle avoidance included in red. resolution
   - Give a review of obstacle avoidance algorithms
   - state why tractrix is better, what is tractrix
   - how obstacle avoidance is easily implemented
3. - State that particularly interesting is the case of motion through ducts, endoscopy and inspection
   - How the tractrix method as is is difficult to implement
   - Explain the motive of this paper
   - Contents of the paper

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2 Path planning in 2D duct

In this section, we look at the path planning strategy of hyper-redundant manipulator passing through a specified 2 dimensional planar duct and given path. In this approach, we first consider last link of hyper-redundant manipulator given by the co-ordinates x_h and x_t representing the position of the 'head' as well as the 'tail' of the link respectively (refer figure(??). If head is to be moved to a desired location given by x_d, the problem narrows down to finding the co-ordinates of the tail x while maintaining the condition that the co-ordinates of x should always lie within the specified duct. Since the tail of last link is the head of subsequent link, the co-ordinates x now becomes the new desired position of the subsequent link and the procedure is repeated through the other links of the manipulator. For the motion of a link which minimizes its tail velocity, obstacle avoidance is achieved by formulating the problem as:

$$\min_{x} \|x - x_t\| \tag{1}$$

$$\text{sub:} \quad \mathbf{f(x)} > \mathbf{0} \tag{2}$$

where $\mathbf{f(x)} = \mathbf{0}$ is the analytical equation of the surface which has to be avoided. For example, if the tail is to avoid a single obstacle represented by a circle with center (x_c, y_c), the expression $f(x) = (x - x_c)^2 + (y - y_c)^2 > 0$ ensures that the point x always lies outside the circle. in case of complex objects, the same can be modelled as a combination of super-ellipses as shown in [ref]. It is also worth noting that the value of function $\mathbf{f(x)}$ will be higher as the point is farther from the curve $f(x)$; the value being zero on the curve. Hence, this approach can also be imagined as a form of geometric potential field, with zero potential appearing at the surface of the obstacle.

Before introducing the concepts, we look at different ways to specify the duct.

2.1 Specification of 2D planar duct

The simplest way to specify a planar duct in S^2 is by means of an area enclosed by two non-intersecting curves $C_1(u)$ and $C_2(u)$, $0 \leq u \leq 1$ as shown in figure(??). By linearly interpolating the curves using parameter $v, 0 \leq v \leq 1$, we can define the surface $S(u, v) = C^1(1 - v) + C^2(v)$ which will form an area enclosed by the curves. For a given point x, the solution of the equation $S(u, v) = x$ give the parameters $\hat{u}$ and v which when take the values between 0 and 1, can be classified as inside the area S.

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References