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THE BEST WAY OF WORKING SPACE ROBOT WHICH EQUIPS A FLEXIBLE MANUFACTURING CELL COMPONENT OF WELDED IN RAIL FIELD

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ABSTRACT: The industrial robot acts on its operating space under different shapes, namely by manipulating parts, by executing processing technological operations, by measuring specific parameters of products or even of the operating space etc. Many applications and functions performed by a robot reveal an essential characteristic, namely their versatility. Studying the movement of a robot consists of a single well-defined problem but a collection of several problems that are more or less than one other option. Exemplification was performed using MSC NASTRAN program.
KEYWORDS: industrial robot, operating space, movement of a robot, exemplification

INTRODUCTION

The industrial robot acts on its operating space under different shapes, namely by manipulating parts, by executing processing technological operations, by measuring specific parameters of products or even of the operating space etc.

Many applications and functions performed by a robot reveal an essential characteristic, namely their versatility.

Versatility defined as the robot's physical ability to perform various functions and to take various actions in a given technological application is closely related to the structure and mechanical ability of the robot, which in turn determines the configuration of the robot workspace.

Since the workspace of a robot has geometry depending on components and structure of its mechanisms, in this space the characteristic point of the robot must execute motions on trajectories imposed by obstacles to avoid collision. In a first analysis of a robot working space should not be dealt with "obstacles" and can be utilized. "Obstacles" are operating in the area of warehouses or other exhaust retrofit devices of flexible robotic cell in which all components must interact.

Trajectory through "obstacles" can be chosen so that we can avoid collisions with maximum probability.

THE STUDY

Studying the movement of a robot consists of a single well-defined problem but a collection of several problems that are more or less than one other option.

The robot is becoming a more autonomous mechanical system that increases the need for automatic trajectory planning in its development.

The simplest planning problem assumes that the robot is only moving object in space which does not possess dynamic properties thus avoiding temporal problems.

It also considers that the robot does not come into contact with surrounding objects, thus avoiding problems of mechanical interaction.

These considerations turn the physical planning problem into a purely geometric problem.

Furthermore it is considered that the robot is only moving rigid solid which is limited only by the obstacles.

With these simplifications the basic problem of planning robot trajectories can be formulated as follows:

- let's consider A a single solid or rigid (robot) that moves in a Euclidean space W, called workspace, represented by Rn, n = 2 or 3; it's movement is not limited by any restriction on kinematics.
- let's consider B1,...,Bq fixed rigid objects (obstacles) distributed in well defined positions in working space W;
- knowing the position and orientation, at baseline, the robot, and final finishing position and orientation of this workspace W, generate a path specifying a continuous sequence of positions and orientations of A starting from the initial configuration (position and orientation), avoiding the contact with obstacles Bj and finishing in the final configuration (position and orientation) final;
- if such a path does not exist, "error" must be reported.

It is obvious that although the basic planning problem is super simplified it is still a difficult problem with many solutions and direct extensions to more complicated issues.

Objectively mobile object (the robot the characteristic point) in such a matter is referred to in the literature as "flying objects".

The basic problem involves the robot path planning through exactly the trajectory generated by the planner. It is also assumed that both the geometry and robotics as well as obstacles positions are known with precision. In reality no planning problem meets these assumptions. Moreover, they control their robots and geometric patterns are not precise. Since the robot has no a priori information about the *desktop, it must be based on runtime its sensory system for recording information necessary to achieve the task. It must work in exploring space and solve the problem of planning in the presence of uncertainties.*

The problem is to calculate the trajectory generation based on data received from the motion planner sizes order to ensure passage of the robot through the established points.

Generation of movement can be made directly in the space coordinates kinematics couplings, or operational area.

Navigation strategy refers to determining how (methods) to move the robot according to the type of task performed.

Modelling space implies establishing navigation maps in the considered space.

Modelling methods known in literature are [1-5]:

- *uniform grid method;*
- *tree method;*
- *heterogeneous grid method;*
- *convex polygon method;*
- *method of crossing points.*

Evolution of the robot in the workspace imposes the statement that the space of configurations SC is intrinsically independent of the choice of reference systems SA and SW.

Trajectory planning problem in the presence of obstacles can be expressed as: given a workspace populated with obstacles known through their borders, and by moving objects, must determine a path without collisions with obstacles in bringing mobile objects in the final initial configuration.

The problem can be approached in two ways global or local, hence the two types of planning methods: global and local.

Application of global methods require complete knowledge of the working space "in advance", modelling proper clearance, research and selection of all possible paths of a certain trajectories corresponding to a minimum cost criterion. Such a method guarantees the existence or absence of a solution. Also global planning methods can be easily adapted to the off-line programming.

Applying a local method requires partial knowledge of the workspace.

Such a method does not guarantee reaching the final configuration, but the advantage of good real-time adjustments.

In both cases, solving the planning problem involves solving geometric problems (pure geometry) or combine geometry with kinematics and/or dynamics.

In such situations often are used the results of algorithmic geometry.

In general the application of planning methods must meet certain restrictions such as: the safest way, the shortest path, etc.

ANALYSES, DISCUSSIONS, APPROACHES AND INTERPRETATIONS

Analyzing the best methods in place of the theoretical and the application can highlight the road map method, exact cell decomposition method and the potential field method. Of these potential field method treats the robot represented as a point in configuration space, that as a particle under the influence of an artificial potential field U whose local variations reflects "structure" of the free space.

Potential function is defined as the amount of free space on an attractive potential, which attracts the robot toward the final configuration, and a repulsive potential, which removes the robot from obstacles.

The method was originally developed as an "on line" method to avoid collisions to be applied when there is no model of obstacles, in advance, but they may refer to during the execution of movement. In particular, the procedure can lock in a local minimum of potential function.

This deficiency can be corrected by calculating the finite element method applied to study a potential field.

Starting from the potential field finite element method we propose, as an effective tool for the analysis of optimum road space of the robot.

Thus we suggest that the workspace of a robot to be modelled as a homogenous body which is dependent on structure geometry of components and obstacles.

In this space to work tasks the robot must go through the obstacles imposed trajectories which it has to avoid.

The road through the obstacles can be chosen so that to avoid the maximum probability collisions. If we accept that two neighbouring obstacles behave as two sources of the same physical stationary field and consider that the moving of the characteristic point is carried on the same potential trajectory as that of the resulting field we can select a family of trajectories corresponding to a certain field potential in a given interval.

In the application illustrated in Figure 1 the working space was modelled as a homogeneous body with known thermal characteristics.

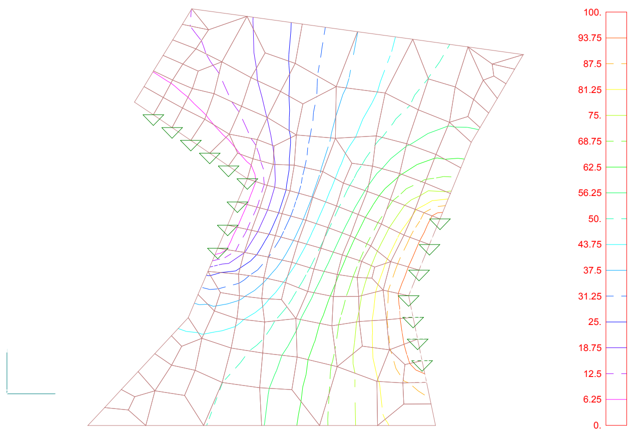

Figure 1 Thermal analysis of a working space modelled as homogeneous body found in a field where the heat source hot / cold data are boundaries of obstacles.

Obstacles are considered as being „hot" or "cold" areas/sources on the boundary of the considered working space as being a homogenous body on which a thermal field is applied from the hot/cold sources (modelled obstacles).

Applying the finite element method analysis facility on the thermal model workspace the outcome is isothermal surfaces. From these areas we can define *curves obtained by modelling which can be trajectories of the characteristic point.*

Using the family of isothermal surfaces in the average temperature (resulting from thermal finite element analysis) on this can reside optimum trajectories to be passed.

So configurations libraries can be built-up for the working space and trajectories to pass, respectively located on the average temperature isothermal surface.

Illustrated in Figure 1 is a workspace of a robot modelled as homogeneous body found in a field where heat sources hot / cold data are borders of the obstacles that need to avoid in his motion.

Thermal finite element analysis on the isothermal model gives us the results. The treaty was exemplified in the plan but can be generalized in three-dimensional space. Most times one of the 3D motion parameters can be imposed by the kinematics couplings which controls programming. Applications can be treated and depending on who is involved in the process robot. The most complex situation is found in welding rail vehicle structures.

CONCLUSIONS

A key issue in the field of industrial robots operation (i.e. programming the optimal path of motion) enjoys the benefits of programs devoted to finite element analysis to allow for applying the "potential field method" as an analysis of a stationary thermal field.

Exemplification was performed using MSC NASTRAN program.

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