Incorporating Learning in Motion Planning Techniques *

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Abstract

This paper proposes a solution for grasp planning that are applicable to a dynamic environment by mainly using information extracted from robot sensors. In this way we avoid the problem of maintaining a consistent internal workspace representation. The solution combines the planning of the motion and the search for stable grasps using artificial force fields and a direct workspace representation.

1 Introduction

A necessary condition for an intelligent robot system to be able to deal with real-world applications is the capability to use sensory information to plan actions according to the current state of the workspace. Planning in a dynamic environment implies that we can not rely only on a purely geometric and symbolic representation. Even if we could detect some of the unexpected changes it would be very difficult to represent them and all of their consequences in this representation.

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We will here present a solution for the grasping problem for automatic assembly which combines motion planning techniques using a potential field approach and pictorial, analogical representations. Artificial force fields are a technique to obtain from the representation of the obstacles an implicit functional model for continuous control[3].

Grasp trajectories result from attraction of a grasp device toward the target object according to artificial force fields. In addition, ad-hoc grasp techniques and heuristics to overcome local minima are used.

The method will be illustrated using a two-fingered hand and an image showing the silhouette of the assembly parts.

The following section gives an outline of the grasp planning technique. For a more detailed description we refer to [1].

2 Grasp Planning

Grasp planning is the process of planning the collision-free motion of the gripper fingers around an object to obtain a stable configuration for manipulating the part. Traditional grasp planners, e.g. [2][5] start by analysing the object's contour to determine the set of contact points for the gripper that guarantee a good balance between forces and torque. Next it is necessary to check whether the chosen contact points are reachable by the gripper and whether it is attainable from a given initial configuration. For a cluttered workspace these last two checks require substantially more computation and are not always guaranteed to find a solution.

In our method the grasp planning is guided by an artificial potential field over the image of the workspace containing the target object. This field is obtained by a combination of two number propagating processes. A first one serves to attract the fingers towards the object and starts from the contour of the target and propagates over the free space. A second field is used to improve the quality of the grasp by covering aspects of grasping that the system does not explicitly handles, like stability at perturbations or the objects weight. It is obtained by a second propagation process starting from the center of gravity of the object through the object's cells and the free space cells. This second field attracts the fingers closer to the center of gravity. Instead of the center of grvity, a different point on the target object can be chosen to attract the gripper, e.g. for an insertion task it is necessary to grasp the object at one of its ends. The total potential value of a gripper configuration is computed as a combination of the field value in control points defined on the fingers surface.

The difference with motion planning methods using grid fields as in [4] is that the goal configuration is not explicitly known at the beginning. The objective is to find *some* configuration that satisfies the conditions of a stable grasp. This is done by attracting the fingers towards the object using the artificial force field. When contact between fingers and object is detected, the stability of the grasp is checked to determine whether a satisfying grasp is found and the search can be stopped.

Collision checking is done by simulation of the configurations in the image.

Starting from a given configuration, the search for a grasp proceeds according to the following steps:

1. The potential value is computed for all neighbour configurations (i.e. by making small changes for every degree of freedom). From these, the collision free configuration with the smallest value is chosen and added to the path. If no satisfying configuration can be found a backtracking process is started.

2. Step one is repeated until contact between the inside of the fingers and the target object is detected.

3. At this moment the stability of the configuration is checked by evaluation of the obtained contact. If this test fails the search proceeds from step 1.

4. Once a stable grasp is found, a local exhaustive search can be used to find possible better grasps (e.g. more contact or closer to the center of mass) near the first one.

5. To facilitate the search for grasps close to the center of mass, a retraction strategy, i.e. shortly making the field repulsive to open the gripper, can be used.

The step size for the neighbour configurations that is chosen in step 1 depends on the distance towards the target object. It decreases when the gripper comes closer to the target to be able to match the fingers closely with its contour.

Figure 1: Example of a grasp path for a gripper using camera images

Though this method usually finds a solution quite fast, it is possible that for a given initial configuration no solution is possible because of the chosen discretisation or because a path simply does not exist. By chosing a smaller granularity for the discretisation or by changing the start position it can be possible to come to a solution.

Figure 5 shows an example of a grasp path found using camera images of an assembly workspace. The main advantage of the method is that the difficult problem of planning the collision free motion for a gripper is treated as a priority and in an effective way. The use of simulation in the workspace based on attractive fields avoids the computation of the complete free C space which is a time-saving advantage over traditional planners.

3 Conclusion

In this paper we have shown a method for grasp planning for automatic assembly based on camera images and easy-to-compute force fields which make it especially applicable for dynamic environments.

The grasp planning differs from the traditional methods by handling the problem of planning the collision free motion for the gripper as a priority and in an efficient way avoiding the computation of the free configuration space.

We have tested our methods for grasping planar objects in a real-world assembly cell. Exploiting the current state of the art in in robot vision we will be able to extend the grasping method for arbitrary objects in 3D.

References

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