SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

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SHAPE MODELING AND 3-D RECOGNITION USING VISUAL ID-TAGS FOR SPACE ROBOTS

Abstract

The 3-D model of working environment is indispensable for autonomous space robots to perform safe navigation and manipulation. In most cases, acquisition of the 3-D model is a costly task because it needs elaborate measurement hardware and complicated processing of the noisy data.

We propose a new method of shape modeling which enables an easy 3-D recognition in unknown artificial environments. We utilize visual ID-tags (tags) attached to walls and objects. We get the ID and the position (location and orientation) of tags by a single camera. We assume that each tag defines the tangent plane of the object, and that each plane divides the space into two regions, which are the space-side (0) and the object-side (1). Then, we represent the object region by a combination of boolean operations of all such divisions, which becomes a polyhedron. In this way, we generate approximate 3-D models of the environment.

In our method, the viewpoint information is not used because the observation data are the relative positions between the tags. The observation is done by a single free-moving camera. It does not require any prior knowledge about the environment, except the size of the tags.

In order to make a 3-D model, the positions of the tags (planes) must be reconstructed, and then, the object region must be extracted. We developed an estimation method which calculates the configuration of all tags, minimizing the errors of both rotation and translation. This method is unique in that it decides the whole configuration based on only the local data. We also devised a method which extracts a polyhedron region using boolean operations on all tangent planes. This method is applicable to modeling of both convex object and concave space.

We conducted the shape modeling experiments, targeting some objects and an intravehicular shape. The generated models had sufficient accuracy for approximation models. Our method showed its availability in approximate 3-D modeling of the environment.

We also developed a system utilizing constructed models. In the system, the models are registered to a database together with each corresponding tag-ID. When a robot detects a tag, it retrieves and loads the corresponding object model, which is superimposed on the real object. Thus, this system helps robots in object recognition and localization in 3-D environment. We conducted some experiments, and demonstrated the usefulness of the system in space robotics applications such as recognition, navigation and manipulation.