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A robotic assembly procedure using 3D object reconstruction

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The use of robotic systems for rapid manufacturing and intelligent automation has attracted growing interest in recent years. Specifically, the generation and planning of an object assembly sequence is becoming crucial as it can reduce significantly the production costs and accelerate the full-scale product delivery. This work lies within the category of intelligent assembly path planning methods and an object assembly sequence is planned to incorporate the production of an object's volumetric model by a multi-camera system, its three-dimensional representation with octrees and its construction implemented by a 5 d.o.f. robot arm and a gripper. The final goal is to plan a path for the robot arm, consisting of predetermined paths and motions for the automatic assembly of ordinary objects.

The first step of the procedure is the image acquisition and the calibration of the multi-camera system. The acquired calibrated image sequence is then further processed to result to the first approximation of the 3D model. To begin with, every image is projected into an array of pixels and an accurate image thresholding method is applied to result the first black and white silhouette of each source photograph. In the next step, the 2D object silhouette is isolated from the background using a robust background subtraction algorithm. Thereafter, the final shape that contains the same silhouettes as the actual object for all views, the so called Visual Hull [1, 2] of the object, is estimated. The outcome of this step is the initial approximation of the 3D model of the object that will be used as an input for the octree decomposition technique and the assembly planning system. An estimation of the quantity and size of the respective wooden cubes in order to assemble the real object is calculated, using the information from the octree formation. Their respective coordinates for their correct positioning inside the scene are then computed along with the assembly instructions for the construction of the real prototype from the robotic arm.

The main contribution of the algorithm is the ability to reconstruct an everyday object using only a four-camera system. The algorithm is fast, simple and the assembly sequence can be transformed to any robotic programming language. Besides, as the computational burden is directly linked to the complexity of the object's geometry, the proposed technique is applicable to industrial smart manufacturing systems, rapid prototyping cells and standard robotic and machine vision applications.

Figure 1: The major steps of the procedure from left to right: Image acquisition by the four-camera system, background subtraction, assembly planning using a robotic system, final object assembled by wooden cubes.

References

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