SEGMENTATION OF RANGE IMAGES BY PIECEWISE APPROXIMATION WITH SHAPE CONSTRAINTS

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RESUME

L'approximation fonctionnelle de l'image est une approche très utile pour la segmentation des images de profondeur (3D). Un algorithme de segmentation hiérarchique avec optimisation par étape est utilise pour transformer un problème d'optimisation global en un problème d'optimisation séquentielle. Le critère d'étape correspond alors à l'accroissement de l'erreur d'approximation produit par la fusion de deux segments. Un modèle d'approximation par plan incliné est utilisé pour segmenter une image de profondeur formée de polyèdres, dont les résultats sont analysés. Des contraintes sur la longueur des contours des segments et sur leur forme sont ensuite ajoutées pour améliorer les résultats.

ABSTRACT

Piecewise functional approximation of picture is shown to be a useful tool for the segmentation of range (3D) image. A hierarchical step-wise optimization algorithm is employed to transform the global optimization problem into one of sequential optimization. The step-wise criterion then corresponds to the increase of the approximation error produced by the merge of two segments. The segmentation results of range image of polyhedra are shown with the utilization of a planar approximation model. Constraints on segment contour length and segment shape is then added to improve the results.

KEYWORDS: Three-dimensional vision, hierarchical segmentation, picture approximation, segment shape.

I - INTRODUCTION

Picture segmentation often constitutes the low-level processing stage of a picture analysis system. An image is thus segmented into regions that roughly correspond to surfaces or parts of objects of the scene. Constant gray level regions or more generally, planar regions are commonly used as "primitives". In robotics applications, the scene could be regarded as composed of polyhedra, cylinders, spheres, and other relatively simple curved objects. The identification of the objects can then be made from a range (3D) image where the "gray level", f(i,j), corresponds now to the elevation of the object surface at position i,j. A segmentation process would thus be used to distinguish each of the surfaces, and a higher level process would combine these regions to identify the objects. Each segment could therefore be represented by a function that approximate the corresponding surface.

Haralick [5] presents a facet model based upon functional approximation. The picture is divided into overlapping cells, and the slope of an approximating plane is calculated for each cell. The slope value is used to decide whether an edge occurs between cells, otherwise the cells are merged into a same region.

Pavlidis [7], [8] presents the picture segmentation as a problem of piecewise functional approximation. Using approximation theory, he derives an algorithm for waveform approximation which locally optimizes an error criterion [7]. He also presents an algorithm where a picture is sliced into thin strips [8]. Each strip is segmented and approximated by polynomials. Then, adjacent segments with similar polynomial coefficients are merged into regions.

Horowitz and Pavlidis [6] propose a split-and-merge approach using a pyramid data structure. The data structure defines the way in which segments can be merged or split. A pyramid is a stack of regular picture blocks of decreasing sizes. The picture blocks (or segments) of one level are split into four regular sub-parts to form the next lower level. A pyramid can be regarded as a segment tree where each node corresponds to a