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AUTOMATIC DOMAIN DECOMPOSITION FOR RADIAL BASIS MESHLESS METHODS IN SOLVING PROBLEMS WITH CONCAVITY AND SINGULARITY

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Abstract. Radial basis functions(RBFs) has been used for interpolating scattered points before they are used in solving PDEs. RBFs have the advantage that they do not require a mesh which can be difficult and time consuming to construct especially in three dimensional cases. However, being global smooth functions, RBFs have problems in modelling entities with discontinuity and concavity. Domain decomposition is a solution to both problems. In this paper, we introduce a method to automatically decompose any object into a number of domains so that each domain would have no concavity. The method is to form a constrained Delaunay triangulation of nodal points on the boundary of the object. The concavity can then be discovered by identifying groups of external triangles that are enclosed by the object. Then each domain is modelled by a separate RBF. Smoothness between different domains is maintained by using the overlapping domains method.

Keywords. Radial basis function , Domain decomposition, Singularity, Concavity .

AMS (MOS) subject classification: 65N35, 65N55.

1 Introduction

The RBF methods have been found to have major advantages over the classical finite element or finite difference methods. One of these advantages is that it does not require the construction of an underlying mesh. This allows it to handle complicated boundaries with concave surface more efficiently. The basic concept of the RBF method is described below.

The radial basis functions were originally devised for scattered geographical data interpolation by Hardy [1], who introduced a class of functions called multiquadric function in the early 1970's. The basic idea of the RBF interpolation is to approximate an unknown function, $\{f(\mathbf{x}) : \mathbf{x} \in \mathbb{R}^d\}$ by an interpolant, say $\{\widehat{f}(\mathbf{x}) : \mathbf{x} \in \mathbb{R}^d\}$ at a set of N distinct data points $X = \{\mathbf{x}_j : j = 1, 2, \cdots, N\}$. Let $\Phi : \mathbb{R}_+ \to \mathbb{R}$ be a set of positive definite radial basis functions defined by

$$\Phi = \{\phi\left(\|\mathbf{x} - \mathbf{x}_j\|\right)\} \quad \mathbf{x},\, \mathbf{x}_j \in \mathbb{R}^d$$