2005 Paper 7 Question 3

Advanced Graphics

Brian and Geoff Wyvill developed a blobby object modelling method where the blobby object is defined by a number, n, of centres, $\mathbf{P}_i$, each with an associated radius, R_i. They define a function

$$g(r, R) = \begin{cases} 1 - \frac{4}{9}\frac{r^6}{R^6} + \frac{17}{9}\frac{r^4}{R^4} - \frac{22}{9}\frac{r^2}{R^2}, & r \le R \\ 0, & r > R \end{cases} \tag{1}$$

and sum the contributions from all centres to give a function over all space

$$F(\mathbf{P}) = \sum_{i=1}^{n} g(|\mathbf{P} - \mathbf{P}_i|, R_i) \tag{2}$$

The surface of the blobby object is defined as all points, $\mathbf{P}$, where

$$F(\mathbf{P}) = \tfrac{1}{2}. \tag{3}$$

(a) Sketch, in 2D, the 2D blobby "surface" for each of the following cases:

(i) $n = 2$, $\mathbf{P}_1 = (0, 0)$, $R_1 = 2$, $\mathbf{P}_2 = (4, 0)$, $R_2 = 2$;

(ii) $n = 2$, $\mathbf{P}_1 = (0, 0)$, $R_1 = 2$, $\mathbf{P}_2 = (2, 0)$, $R_2 = 2$;

(iii) $n = 2$, $\mathbf{P}_1 = (0, 0)$, $R_1 = 2$, $\mathbf{P}_2 = (3, 0)$, $R_2 = 4$. [6 marks]

(b) Outline an algorithm which will generate a reasonable approximation, in 3D, to the 3D blobby surface (equation 3) which could be drawn by a graphics card that can draw only triangles. [10 marks]

(c) Describe variations of equation 2 which allow for:

(i) CSG union of blobby objects;

(ii) CSG intersection of blobby objects;

(iii) CSG difference of blobby objects. [4 marks]