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Equation of the Result of Second-Order Surfaces

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Abstract:

In this article, we gave brief information about the product equation of second-order surfaces.

Kali word: hyperbolic paraboloid, ellipsoid, cylindrical surface, function.

A set of points defined by a second-order algebraic equation on an affend is called a second-order surface. The equation of the product plane given in the figure is transferred to the point $M_0(x_0y_0z_0)$

$$(x-x_0)(A_1x_0+B_1y_0+B_2z_0+C_1)+(y-y_0)(A_2y_0+B_1x_0+B_3z_0+C_2)\ +$$

$$+(z-z_0)(A_3z_0+B_2x_0+B_3y_0+C_3)=0 \qquad (2)$$

we saw that it will look like this. If the left side of (1) is defined as $F(x,y,z)$, and first in (1) x (considering y and z constant), then in y (where x and z are o is considered constant), finally we take derivatives with respect to z (taking x and y as constant).

$$F'_x(x,y,z)=2\,A_1x+2B_1y+2B_2z+2C_1=2(A_1x+B_1y+B_2z+C_1),$$

$$F'_y(x,y,z)=2\,A_2y+2B_1x+2B_3z+2C_2=2(A_2y+B_1x+B_3z+C_2),$$

$$F'_z(x,y,z)=2\,A_3z+2B_2x+2B_3y+2C_3=2(A_3z+B_2x+B_3y+C_3),$$

If we find the values of these functions at the point $M_0(x_0y_0z_0)$

$$F'_{x_0}(x_0,y_0,\ z_0)=\ 2(A_1x_0+B_1y_0+B_2z_0+C_1),$$

$$F'_{y_0}(x_0,y_0,\ z_0)=\ 2(A_2y_0+B_1x_0+B_3z_0+C_2),$$

$$F'_{z_0}(x_0,y_0,\ z_0)=\ 2(A_3z_0+B_2x_0+B_3y_0+C_3),$$

of these

$$\frac{1}{2}F'_{x_0}(x_0,y_0,\ z_0)=\ A_1x_0+B_1y_0+B_2z_0+C_1,$$

$$\frac{1}{2}F'_{y_0}(x_0, y_0,\ z_0) = \ A_2y_0 + B_1x_0 + B_3z_0 + C_2,$$

$$\frac{1}{2}F'_{z_0}(x_0, y_0,\ z_0) = \ A_3z_0 + B_2x_0 + B_3y_0 + C_3,$$

Let's put these values in (2).

$$(x - x_0)\frac{1}{2}F'_{x_0}(x_0, y_0,\ z_0) + (y - y_0)\frac{1}{2}F'_{y_0}(x_0, y_0,\ z_0) + (z - z_0)\frac{1}{2}F'_{y_0}(x_0, y_0,\ z_0)$$

Or to put it more succinctly,

$F'_{x_0}(x - x)+ F'_{y_0}\ (y - y_0)+ F'_{z_0}(z - z_0) = 0$ (3)

This equation is the equation of the test plane transferred to the second-order surface in the most convenient form.

We note that $F'_{x_0}, F'_{y_0}, F'_{z_0}$ cannot be equal to zero at the same time, otherwise the point M will remain a specific point for the surface.

Using equation (3), let's write the equation of the test plane transferred to the second-order surface given by the canonical equations.

$a)\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$ Let's write the equation of effort transferred to the point $M_0(x_0y_0z_0)$ of the ellipsoid.

Here

$$F(x, y, z) = \ \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} - 1 = 0,$$

$$F'_X = \frac{2}{a^2}x, F'_y = \frac{2}{b^2}y, F'_z = \frac{2}{c^2}z.$$

So,

$$F'_{x_0} = \frac{2x_0}{a^2}\ , F'_{y_0} = \frac{2y_0}{b^2}, F'_{z_0} = \frac{2z_0}{c^2};$$

Putting these in (3) and considering that the point M_0 belongs to the ellipsoid,

$$(x - x_0)\ \frac{2x_0}{a^2} + (y - y_0)\ \frac{2y_0}{b^2} + (z - z_0)\ \frac{2z_0}{c^2} = 0,$$

From this

$$\frac{xx_0}{a^2} + \frac{yy_0}{b^2} + \frac{zz_0}{c^2} = 1. \quad (4)$$

$b)\ \frac{x^2}{p} - \frac{y^2}{q} = 2z$ let's write the equation of the test plane at the point $M_0(x_0y_0z_0)$ of the hyperbolic paraboloid. Here

$$F(x, y, z)\ = \frac{x^2}{p} - \frac{y^2}{q} - 2z = 0,$$

$F'_x = \frac{2}{p}x,\ F'_y = \frac{2}{q}y, F'_z = -2$, their values at point M_0

$$F'_{x_0} = \frac{2}{p}x_0\ \ F'_{y_0} = \frac{2}{q}y_0\ F'_{z_0} = -2$$

Let's put these in (3).

$$\frac{2}{p}x_0(x-x_0)+(-\frac{2}{q}y_0)(y-y_0)+(-2)(z-z_0)=0$$

If we consider that M_0 belongs to this surface, the sought equation will be as follows:

$$\frac{xx_0}{p}-\frac{yy_0}{q}=z+z_0. \quad (5)$$

$c)$ $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ let's write the equation of the test plane on the cylindrical surface at its point $M_0(x_0y_0z_0)$.

$$F_x'=\frac{2}{a^2}x\ , F_y'=\frac{2}{b^2}y, F_z'=0;$$

their values at the point $M_0(x_0y_0z_0)$ are $F_x'=\frac{2}{a^2}x,\ F_y'=\frac{2}{b^2}y, F_z'=0$, put it in (3) if

$$\frac{2}{a^2}x_0(x-x_0)+\frac{2}{b^2}y_0(y-y_0)+0(z-z_0)=0$$

Or

$$\frac{xx_0}{a^2}+\frac{yy_0}{b^2}=1. \quad (6)$$

s) $\frac{x^2}{p}+\frac{y^2}{q}=2z$ Let's write the equation of the plane of the elliptic paraboloid at the point $M_0(x_0y_0z_0)$. Here

$$F(x,y,z)\ =\frac{x^2}{p}+\frac{y^2}{q}-2z=0$$

$F_x'=\frac{2}{a^2}x\ \ , F_y'=\frac{2}{b^2}y, F_z'=-2;$ if we put these in (3) and take into account that the point M_0 belongs to the elliptic

$$\frac{2}{p}x_0(x-x_0)+\frac{2}{q}y_0(y-y_0)+(-2)(z-z_0)=0$$

From this

$$\frac{xx_0}{a^2}+\frac{yy_0}{b^2}=3z-z_0. \ (7)$$

Besides these, we can prove any second-order surfaces by formula (3).

Example 1 $\frac{x^2}{27}+\frac{y^2}{12}+\frac{z^2}{75}=1$ construct the equation of the product plane at the point M(3,2,5) of the ellipsoid

Solution: if we transfer this example to the formula (4) derived from (3).

$\frac{3x}{27}+\frac{2y}{12}+\frac{5z}{75}=1\ \leftrightarrow\ \frac{x}{9}+\frac{y}{6}+\frac{z}{15}=1\ \leftrightarrow\ 10x+15y+6z-90=0$ the plane equation is derived.

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