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Synthesize

Recall that we can write the dot product of two vectors as

$$ec{v}\cdotec{w}=|ec{v}||ec{w}|\cos heta$$

where $oldsymbol{ heta}$ is the angle between $oldsymbol{ec{v}}$ and $oldsymbol{ec{w}}$.

Let $\hat{m{u}}$ be a unit vector and $m{ heta}$ be the angle between $abla m{f}$ and $\hat{m{u}}$. Using the definition of the dot product, we have

$$D_{\hat{u}}f = \nabla f \cdot \hat{u} = |\nabla f||\hat{u}|\cos\theta = |\nabla f|\cos\theta. \tag{3.110}$$

We know $|\hat{\pmb{u}}| = \pmb{1}$ because $\hat{\pmb{u}}$ is a unit vector.

Notice that when heta=0, the quantity $D_{\hat{u}}f(x,y)$ is maximal. This means that when \hat{u} is parallel to abla f , the directional derivative of f at (x,y) is maximal. In other words, the gradient is the direction of the maximum rate of change of f.

8. Direction of maximal change

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