Formulas

Formulas and Theorem

Expansion in Orthogonal Basis

If we have an Orthogonal Basis $\{\vec{u}_1, \ldots, \vec{v}_n\}$ in $\mathbb{R}^n$ then for any $\vec{w} \in \mathbb{R}^n$,

$$\vec{w} = c_1\vec{u}_1 + \cdots + c_n\vec{v}_n$$

C_q can be found using,

$$c_q = \frac{\vec{w} \cdot \vec{u}_q}{\vec{u}_q \cdot \vec{u}_q}$$

Orthogonal Projection

Let non-zero $\vec{u} \in \mathbb{R}^n$, and $\vec{y} \in \mathbb{R}^n$. The orthogonal projection of $\vec{y}$ onto $\vec{u}$ is the vector in the span of $\vec{u}$ that is closest to $\vec{y}$.

$$\text{proj}_{\vec{u}}\vec{y} = \frac{\vec{y} \cdot \vec{u}}{\vec{u} \cdot \vec{u}}\vec{u}$$

Also, $\vec{y} = \hat{y} + \vec{z}$ and, $\vec{z} \in W^\perp$

Best Approximation Theorem

Let W be a subspace of $\mathbb{R}^n, \vec{y} \in \mathbb{R}^n$, and $\hat{y}$ is the orthogonal projection of $\vec{y}$ onto W. Then for any $\vec{v} \neq \hat{y}, \vec{v} \in W$, we have

$$||\vec{y} - \hat{y}|| < ||\vec{y} - \vec{v}||$$