In The Name of God.
The Merciful, The Compassionate.

Multivariate Gaussian

$p(\mathbf{x}) \sim \mathcal{N}(\mu, \mathbf{\Sigma})$:

$$p(\mathbf{x}) = \frac{1}{(2\pi)^{d/2}|\mathbf{\Sigma}|^{1/2}} \exp\left[-\frac{1}{2}(\mathbf{x}-\mu)^t\Sigma^{-1}(\mathbf{x}-\mu)\right], \tag{1}$$

where $\mathbf{x} \in \mathbb{R}^d$.

Now suppose $\mathbf{y}$ is a linear transformation of $\mathbf{x}$:

$$\mathbf{y} = \mathbf{A}^t\mathbf{x} \tag{2}$$

where $\mathbf{A} \in \mathbb{R}^{d\times k}$ and $\mathbf{y} \in \mathbb{R}^k$. Then, $p(\mathbf{y}) \sim \mathcal{N}(\mathbf{A}^t\mu, \mathbf{A}^t\mathbf{\Sigma}\mathbf{A})$

Now suppose $k = 1$ and $\mathbf{A}$ is a unit vector $\mathbf{a}$. $y = \mathbf{a}^t\mathbf{y}$ represents the projection of $\mathbf{x}$ onto a line in the direction of $\mathbf{a}$.

Example

If $\mathbf{x} = \{x_1, x_2\}$, then the projection onto x_1 is represented by $\mathbf{a}^t = [1, 0]$. If $y = \mathbf{a}^t\mathbf{x}$, then $y \sim \mathcal{N}(\mu' = \mathbf{a}^t\mathbf{x}, \sigma' = \mathbf{a}^t\mathbf{\Sigma}\mathbf{a})$ and

$$\begin{aligned} \mu' &= [1, 0]\,[\mu_1, \mu_2]^t = \mu_1 \\ \sigma' &= [1, 0] \begin{bmatrix} \sigma_{1,1} & \sigma_{1,2} \\ \sigma_{2,1} & \sigma_{2,2} \end{bmatrix} [1, 0]^t = \sigma_{1,1} \end{aligned}$$