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2] Given: if $||v|| = 1$

$$\frac{(x^{(i)})^T v}{||v||} = (x^{(i)})^T v$$

$$x^T v = \begin{bmatrix} (x^{(1)})^T v \\ (x^{(2)})^T v \\ (x^{(3)})^T v \\ (x^{(4)})^T v \end{bmatrix}$$

3] $$\mu = \frac{x^{(1)} + x^{(2)} + x^{(3)} + x^{(4)}}{4}$$

4] $\frac{1}{4} X^T 1$

5] Scalar projection $= \dfrac{x^{(1)} + x^{(2)} + x^{(3)}}{\sqrt{3}}$

$$\mu = \frac{\frac{x^{(1)}}{\sqrt{3}} + \frac{x^{(2)}}{\sqrt{3}} + \frac{x^{(3)}}{\sqrt{3}}}{3} = \frac{x^{(1)} + x^{(2)} + x^{(3)}}{3\sqrt{3}}$$

6] Scalar projection of μ on v

$$= \frac{\mu v}{||v||}$$

7] $$\frac{1}{4}\left((x^{(1)})^T v + (x^{(2)})^T v + (x^{(3)})^T v + (x^{(4)})^T v\right)$$

$$= v^T \left(\frac{x^{(1)} + x^{(2)} + x^{(3)} + x^{(4)}}{4}\right)$$

$$= v^T \mu$$

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Mean of Scalar projection on to the direction of v is same as Scalar projection of mean sample onto the same direction of vector

8) $\frac{X-\mu}{3} = \sigma^2$

9) $\frac{1}{n}\sum_{i=1}^{n} (v^T x^{(i)} - v^T\mu)^2$

Squared difference between the vector $x^{(i)}$ along the direction of v and mean of projected sample along v

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n} (v^T)^2 [x^{(i)} - \mu]^2$$

10] $\frac{1}{n}\sum_{i=1}^{n} (v^T x^{(i)} - v^T\mu)^2$

$$= \frac{1}{n}\sum_{i=1}^{n} [v^T x^{(i)} - v^T\mu] \times [(x^{(i)T})v - \mu^T v]$$

$$= \frac{1}{n}\sum_{i=1}^{n} [v^T(x^{(i)} - \mu) \times [(x^{(i)})^T - \mu^T] v]$$

$$= v^T \left[\frac{1}{n}\sum_{i=1}^{n} (x^{(i)} - \mu)((x^{(i)} - \mu)^T v\right]$$