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(2) C (covariance matrix) is symmetric

$\Rightarrow$ Its eigenvectors are ortogonal

let $(\lambda_1, v_1), (\lambda_2, v_2)$ be eigenval, eigenvector pairs for C.

$$C v_1 = \lambda_1 v_1 \quad , \quad C v_2 = \lambda_2 v_2$$

$$\therefore \quad v_2^T C v_1 = \lambda_1 v_2^T v_1$$

$$\rightarrow (C^T v_2)^T v_1 = \lambda_1 v_2^T v_1$$

$$(C v_2)^T v_1 = \lambda_1 v_2^T v_1 \quad \text{(C is symmetric)}$$

$$(\lambda_2 v_2)^T v_1 = \lambda_1 v_2^T v_1$$

$$v_2^T v_1 \lambda_2 = v_2^T v_1 \lambda_1$$

since we have $\lambda_1 \neq \lambda_2$

so $v_2^T v_1 = 0$ or v_1 & v_2 are orthogonal

Maximising $f^T C f$

$\rightarrow f$ is eigenvector & by choosing The largest eigenvalue & thus corresponding eigenvectore. We want to maximis $f^T C f$ in perpendicular dir^n

assuming $\bar{f}^T f = 1$

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$$\tilde{J}(f) = f^T C f - \lambda(f^T f - 1)$$

~~on derivation~~ on differentiating

$$Cf = \lambda f \Rightarrow f^T C f = \lambda$$

Now, as $f^T C f$ is maximised when f satisfies $Cf = \lambda f$

so

$f^T C f$ is the eigenvalue, as the largest is already choosen, we will choose 2^{nd} largest eigen value, but we need the corresponding eigenvector to be normal to the initial one.

since C is symmetric its eigen vectors are orthogonal.

$\therefore$ f will be the eigen vector corresponding to the second largest eigenvalue.