The Fisher Linear discriminant uses the criterion function (equation 26).

$$\mathbf{S_i} = \sum_{\vec{x} \in D_i} (\vec{x} - \vec{m_i})(\vec{x} - \vec{m_i})^T \tag{27}$$

$$\mathbf{S_W} = \mathbf{S_1} + \mathbf{S_2} \tag{28}$$

$$\tilde{s_i}^2 = \sum_{\vec{x} \in D_i} (\vec{w}^T \vec{x} - \vec{w}^T \vec{m_i})^2 \tag{29}$$

$$= \sum_{\vec{x} \in D_i} \vec{w}^T (\vec{x} - \vec{m_i})(\vec{x} - \vec{m_i})^T \vec{w} \tag{30}$$

$$= \vec{w}^T \mathbf{S_i} \vec{w} \tag{31}$$

$$\therefore \tilde{s_1}^2 + \tilde{s_2}^2 = \vec{w}^T \mathbf{S_W} \vec{w} \tag{32}$$