decision boundary

$$w^T x + b = 0$$

$\hat{u}$ is $\perp^r$ to decision boundary.

say x is on decision boundary.

x' is on margin . $(w^T x' + b = 1)$

so. $\vec{x'} - \vec{x} = \vec{r}$

$\vec{r}$ is in the direction of $\hat{u}$

$$\therefore \vec{r} = \gamma \hat{u}$$

$$\vec{r} = \gamma \frac{\vec{w}}{\|w\|_2}$$

$$\vec{r} = \vec{x'_i} - \vec{x}$$

multiply $\vec{w}$ on both sides.

$$\vec{w}^T \vec{r} = \vec{w}^T \vec{x'_i} - \vec{w}^T \vec{x}$$

$$\therefore \vec{w}^T \gamma \frac{\vec{w}}{\|w\|_2} = 1 - b - b = 1$$

$$\therefore \gamma \frac{\vec{w}^T \vec{w}}{\|w\|_2} = 1 .$$

$$\gamma = \frac{\|w\|_2}{w^T \vec{w}} = \frac{1}{\|w\|}$$

$$\therefore \text{margin} = 2\gamma = \frac{2}{\|w\|}$$