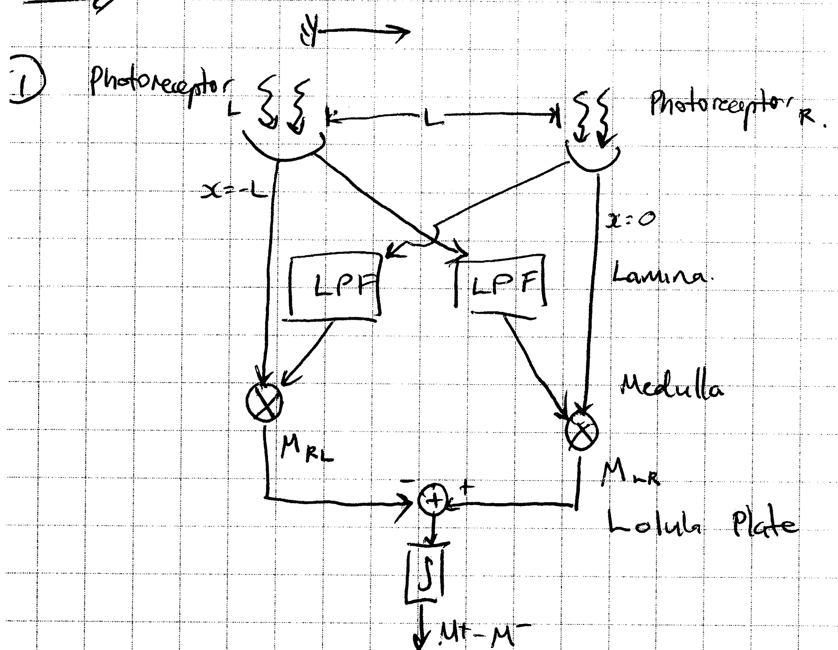
6.003 Recitation, Sections 3 & 4, Friday May 7.

Today:

Signal Processing in the fly's visual system (Reichardt motion detection)

① Basic architecture
② Analysis
③ Plot

①



Key ideas

1) Phase delay cancels motion delay at optimum speed
2) $\underbrace{M_{LR} > M_{RL}}_{\text{vice-versa}}$ for left-to-right motion
3) Together, we get speed & direction of the moving edge.

$$\text{LPF} = H(j\omega) = \frac{1}{1+j\omega\tau}.$$

② Assume we have spatial grating with spatial frequency ω_x and this grating moves past the fly at velocity v. The temporal frequency ω_t of the stimulation at the photoreceptor is

$\boxed{\omega_t = \omega_x v.}$, so the net input at any location x is given by

$$\cos\left(\omega_t\left(t - \frac{x}{v}\right)\right).$$

∴ photoreceptor R input is $\cos(\omega_t t)$, $\{x=0\}$
" L " " $\cos(\omega_t(t + L/v))$ $\{x=-L\}$

$$M^+ = \left\langle \frac{\cos(\omega_t(t + L/v) - \tan^{-1}(\omega\tau))\cos\omega_t t}{\sqrt{1+\omega_t^2\tau^2}} \right\rangle$$ averaging done to integration.

$$M^- = \left\langle \frac{\cos(\omega_t t - \tan^{-1}(\omega_t\tau))}{\sqrt{1+\omega_t^2\tau^2}} \cos(\omega_t(t + L/v)) \right\rangle$$

then simplifying

$$M^+ = \left\langle \cos\left(\omega_t \tfrac{L}{v} - \tan^{-1}(\omega_t\tau)\right) - \cancel{\cos(2\omega_t t + \omega_t L/v - \tan^{-1}(\omega_t\tau))}^{0} \right\rangle \frac{1}{2\sqrt{1+\omega^2\tau^2}}$$

$$M^- = \left\langle \underbrace{\cos\left(\omega_t (L/v) + \tan^{-1}(\omega_t\tau)\right)}_{\text{no time dependence.}} - \cancel{\cos(2\omega_t t + \omega_t L/v - \tan^{-1}\omega_t\tau)}^{0} \right\rangle \frac{1}{2\sqrt{1+\omega^2\tau^2}}.$$

$$M^+ - M^- = \frac{\cos\left(\omega_t \frac{L}{v} - \tan^{-1}(\omega_t\tau)\right) - \cos\left(\omega_t L/v + \tan^{-1}\omega_t\tau\right)}{2\sqrt{1+\omega^2\tau^2}}.$$

$$\Rightarrow M^+ - M^- = \frac{\sin(\omega_x L)\,\omega_t\tau}{\sqrt{1+\omega_t^2\tau^2}\sqrt{1+\omega_t^2\tau^2}} = \underbrace{\sin(\omega_x L)\left(\frac{\omega_t\tau}{1+\omega_t^2\tau^2}\right)}_{\text{If } L\to R \text{ motion becomes } R\to L \text{ motion } \omega_t\to-\omega_t.}. \quad \blacksquare$$

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