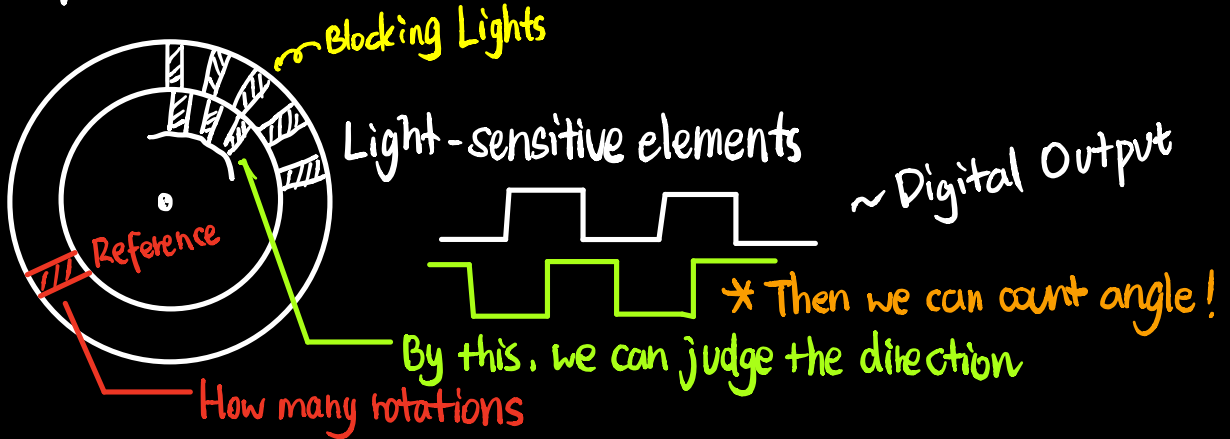
§1. Sensors

1. Characteristic
   - Sensitivity : change according to input
   - Linearity : how linear is the relationship
   - Resolution : smallest measurement increment
   - Response time : how fast to change
   - Measurement Range

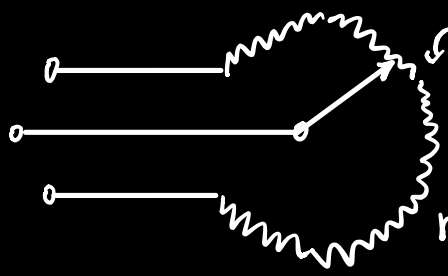
2. Position Measurement

- Optical Encoder



⇒ To improve resolution : take XOR of the two signals

- Potentiometer



We can judge the rotation by varying resistance giving different current

*Noisy!

3. Velocity Measurement

⇒ Simple thought $v = \frac{\Delta p}{\Delta t}$ (Noisy. add LPF)

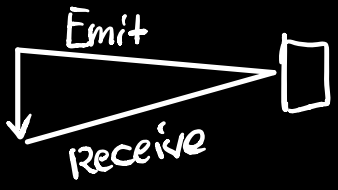
- Inertial Sensors { Gyroscopes, Accelerometers

4. Range Sensors : measure distance to obstacles

- Infrared Sensor

  Triangular measurement

  * Reflection Issues!

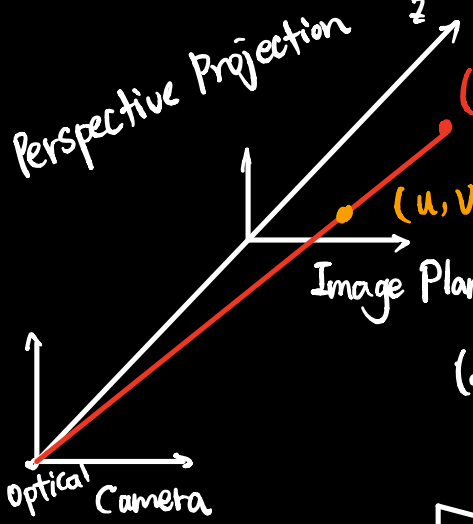


- Ultrasonic Sensor

  Time of flight Measurement

  * Noise issue & Mirror Reflection

5. Vision Sensors



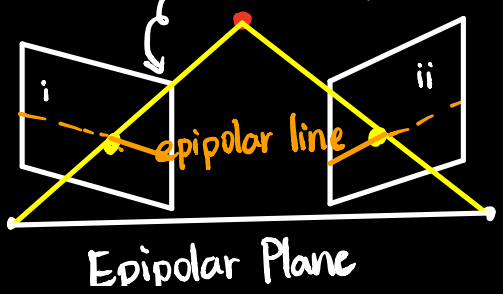
$$\begin{bmatrix} u \\ v \end{bmatrix} = \frac{f}{z}\begin{bmatrix} x \\ y \end{bmatrix}$$

* we can't get 3D point by image

⇒ Stereo Vision

(2 Cameras to measure the depth)

Lines here project to ii lies on epipolar line



- Hard to find Corresponding Point

- Structured Light : Different color light to get correspondence

6. Touch & Proximity Sensor

§2. Actuators : drive robots by using pressure of different res.

1. DC Motors

$\tau_m = k_s \cdot i(t)$ → Input current

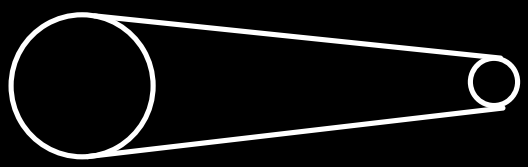
* Energy Loss $\tau_{load} = \tau_m - J_m \frac{d\omega_m}{dt} - b_m \omega_m$ (Damping)

($J_m \frac{d\omega_m}{dt}$: Inertia of motor)

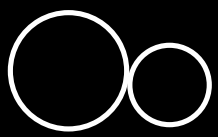
⇒ Stepping Motor

⎍⎍⎍ ~ Every pulse correspond to certain angle

2. Motion Transmission : Gears



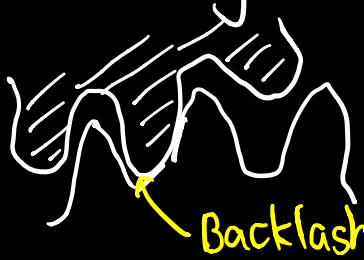
Belt Driven



Gear Ratio

$\frac{v_1}{v_2} = \frac{r_2}{r_1}$

Disadvantage



⇒ The error will accumulate!

Backlash Exists !