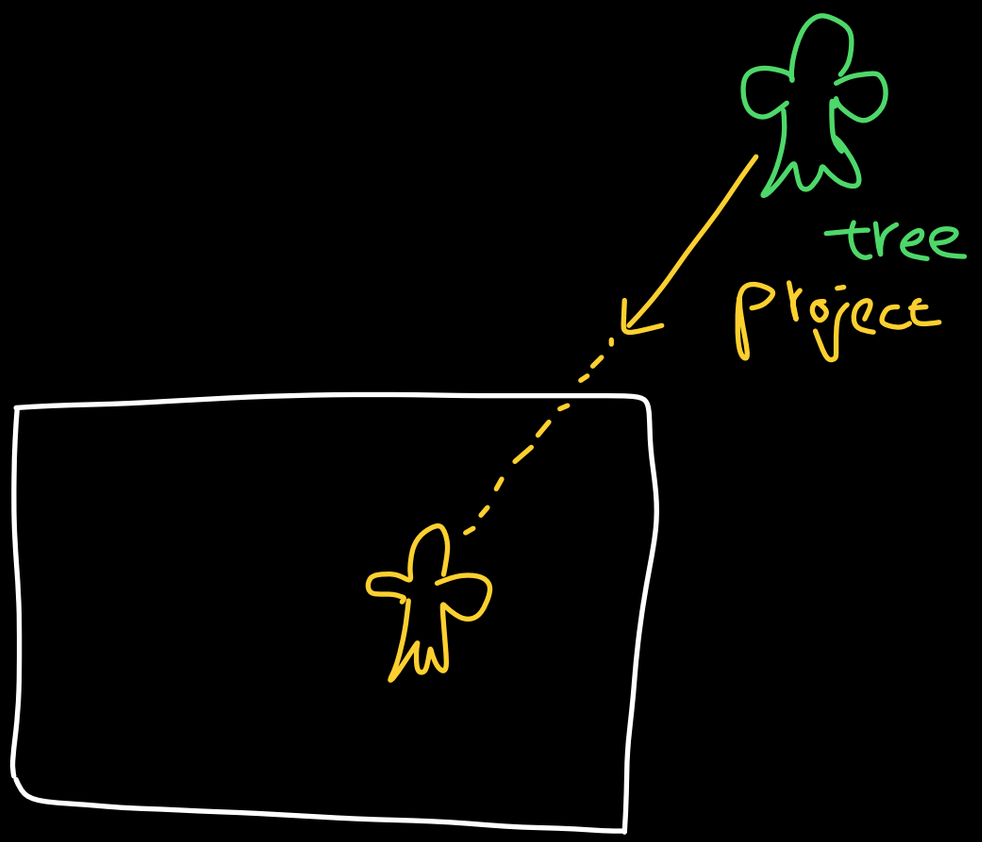
Advanced-3dv-tutorial

From Camera Calibration to Depth Estimation

최준혁

Camera Calibration

직관

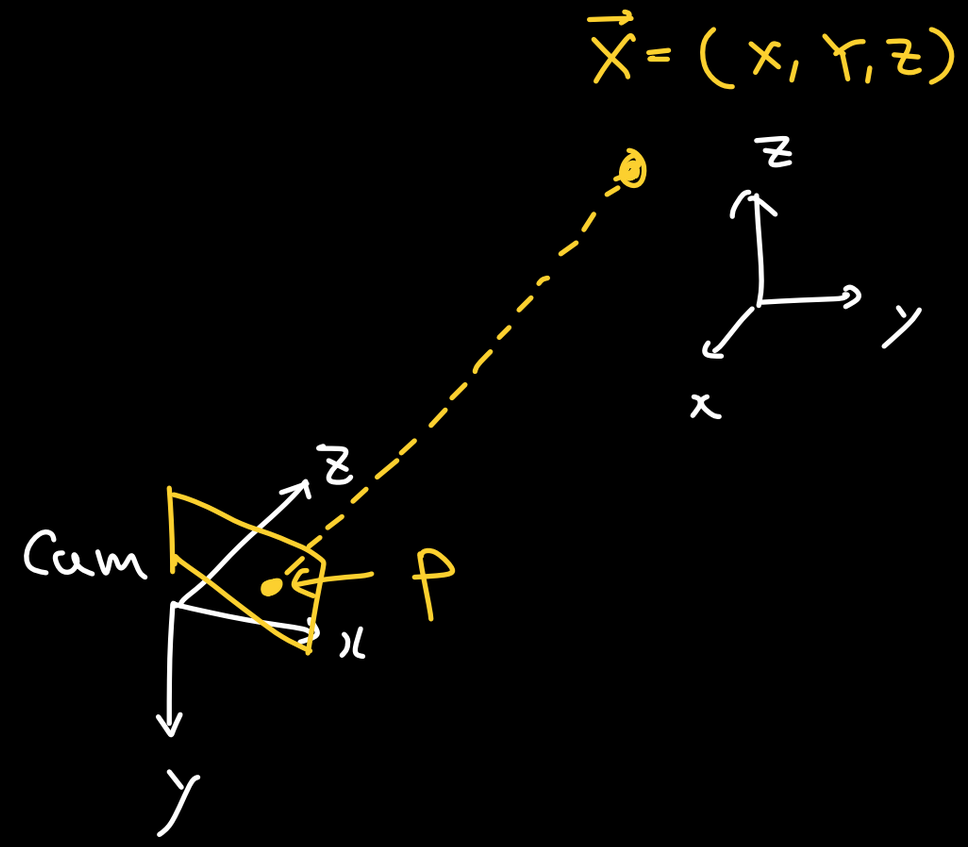


How tree project into Camera?

Camera Calibration

직관

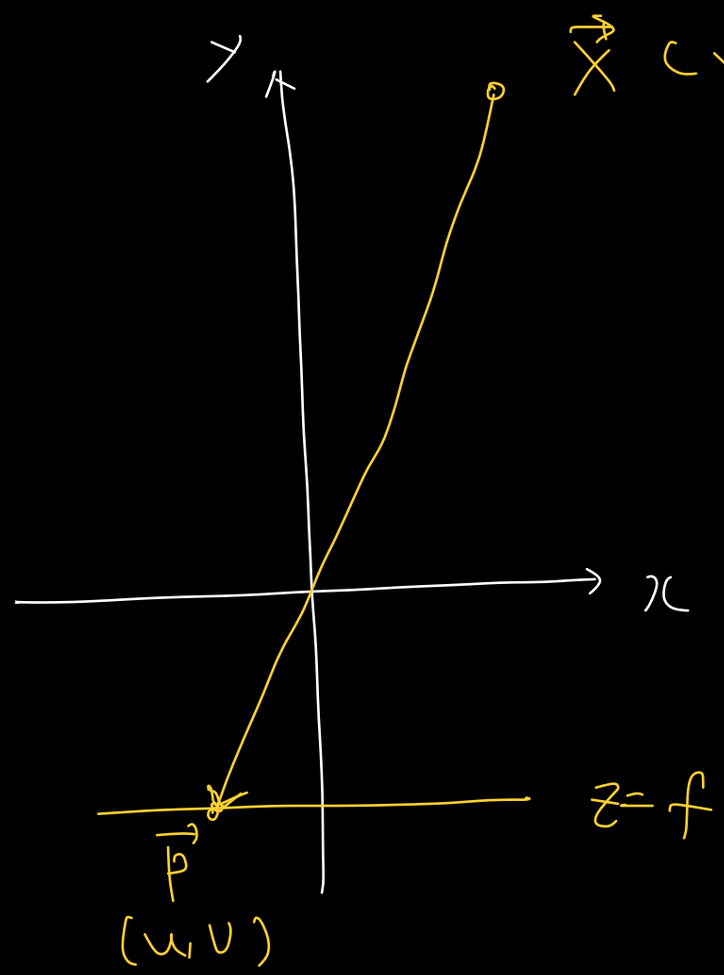
How point in World Coord projects into Camera Coordinate?



How $\vec{X} = (x, y, z) \Rightarrow \vec{p}\,(u, v)$?

Camera Calibration

수식



$\vec{X}\,(x, y, z)$

$\vec{p} = \pi(\vec{X})$

① normalize $\vec{X}$: $\vec{X} \to \frac{\vec{X}}{z} = (\frac{x}{z}, \frac{y}{z}, 1)$

② to $z=f$ plane : $\frac{\vec{X}}{z} \to f \cdot \frac{\vec{X}}{z} = (\frac{fx}{z}, \frac{fy}{z}, f)$

(image plane)

③ pixel plane : $\frac{\vec{X}}{z} + \vec{C} \to (f\frac{x}{z} + c_x, f\frac{y}{z} + c_y)$

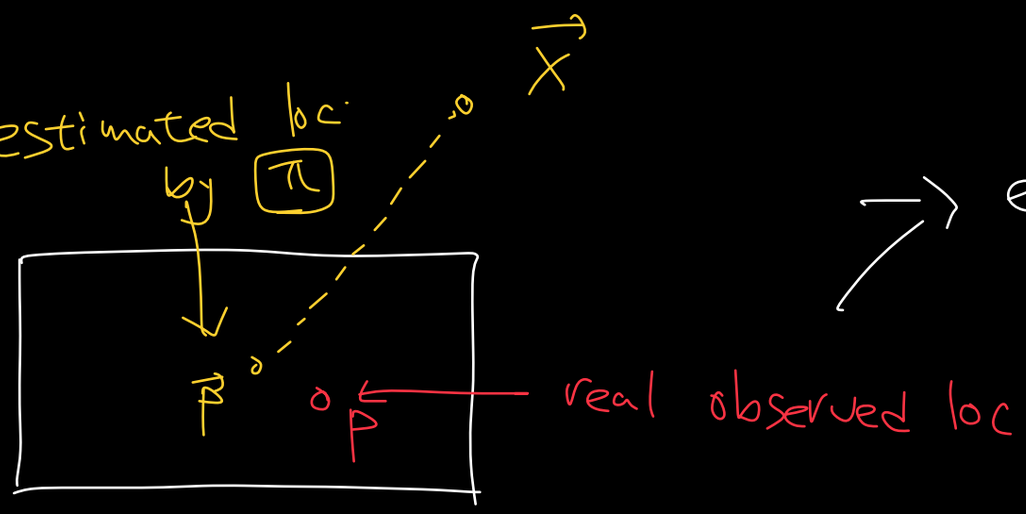
(u, v)

π

Stereo Camera Calibration

수식

How to calibrate ??



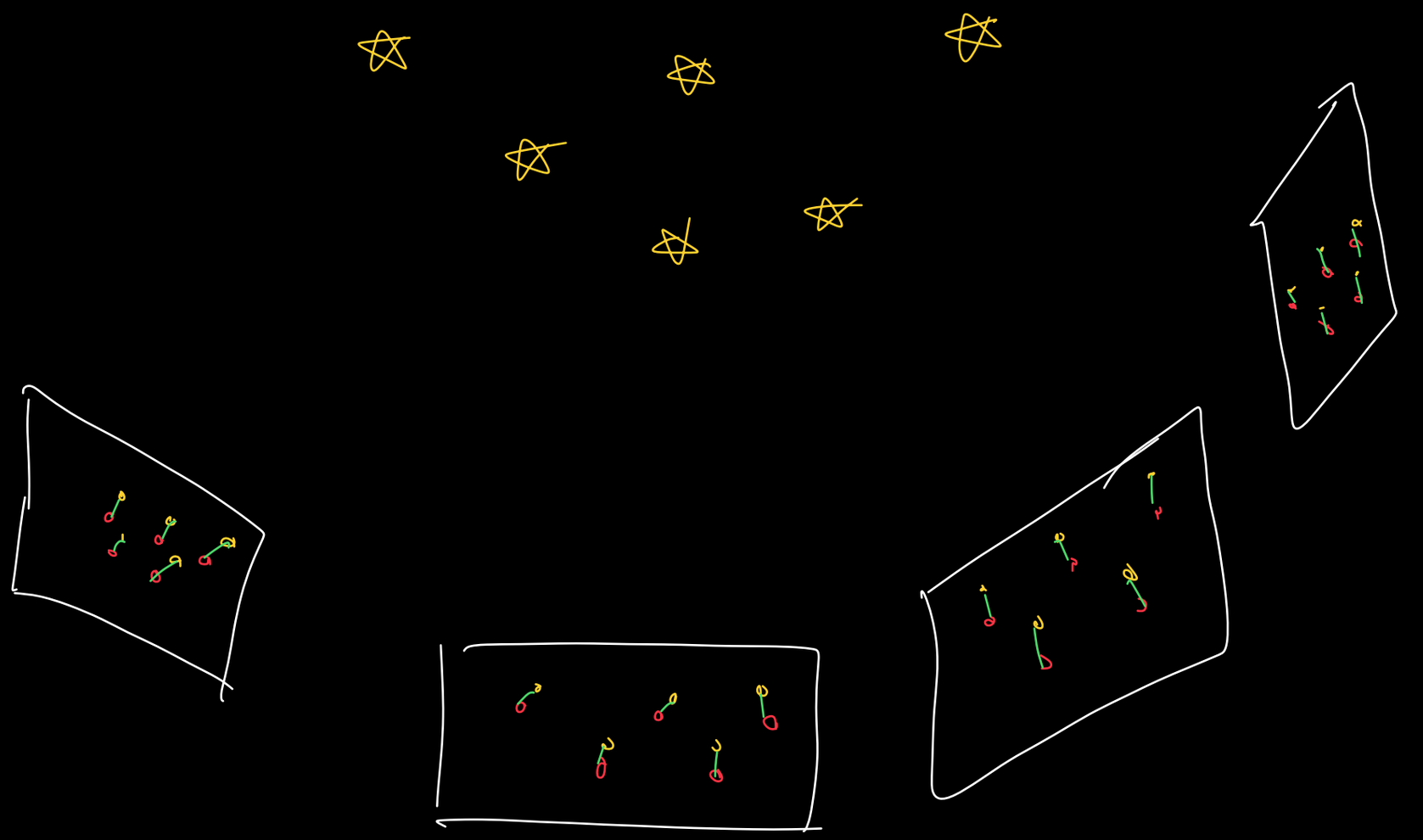
$\rightarrow$ error $= p - \hat{p}$

$= \vec{p} - \pi(\vec{X})$

$\Rightarrow$ need to minimize error by optimizing π params

Stereo Camera Calibration

수식



need to minimize error with many datas

Stereo Camera Calibration

수식

$$\sum_{\text{all frame}} \sum_{\text{all corners}} \left\| \vec{p} - \pi\left(R_w^c \vec{x}_w + t_w^c \right) \right\|$$

⇒ Optimize all frame poses + Camera intrinsic

✡

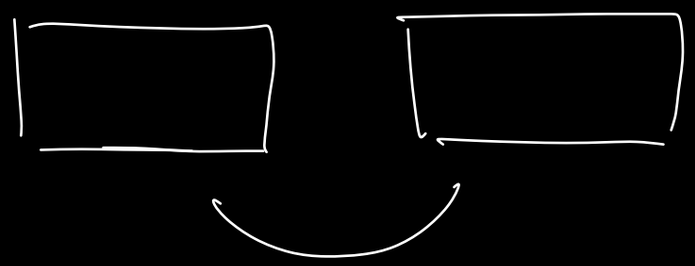
Input : observed pixels loc. known 3d points

Output : all frame poses + camera intrinsic

Stereo Camera Calibration

수식

스테레오 카메라는 어떨까??



$T_{C_1}^{C_2}$ ⇐ Camera 1과 2 사이의 관계식을 아는 것이 목적이다!

Stereo Camera Calibration

수식

$$r = \| \vec{p}_l - \pi_l (R_w^l \vec{X}_w + t_w^l) \|^2$$

$$+$$

$$\| \vec{p}_r - \pi_r (\vec{R}_l^r (\vec{R}_w^l \vec{X}_w + \vec{t}_w^l) + \vec{t}_l^r) \|^2$$

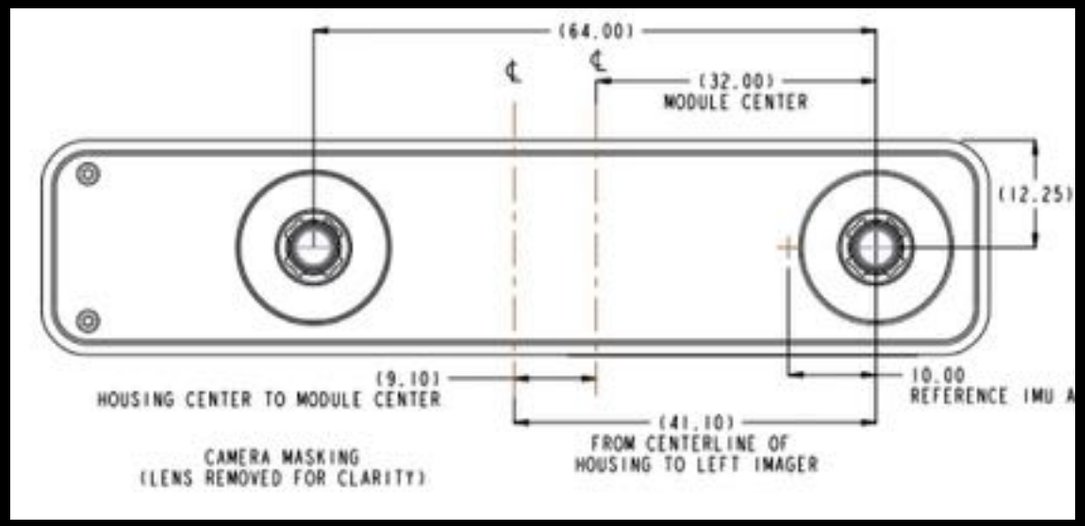
Input: Cam l intrinsic, Cam r intrinsic, Cam l pose,

observed p_l, p_r, X world

Output: R_l^r, t_l^r

Stereo Camera Calibration

실습: Realsense T265



left 와 right 사이거리

6.4 cm!

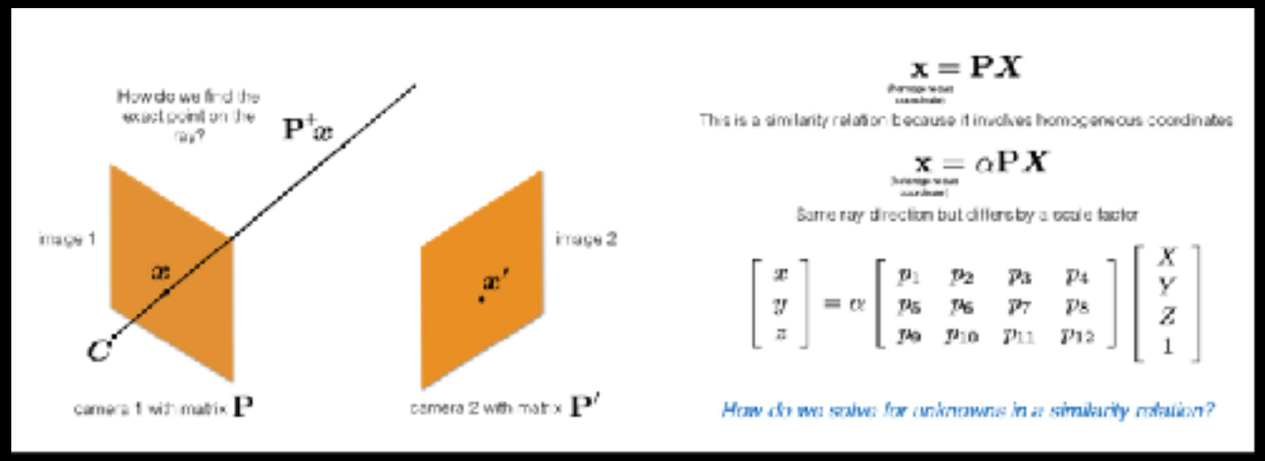
Calibration 결과

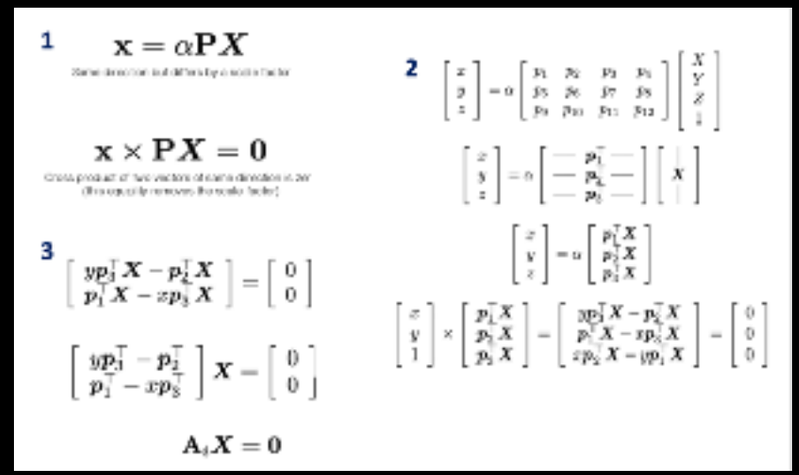
$T_{C_1}^{C_2}$ 의 translation 값 (0.064, 0, 0)

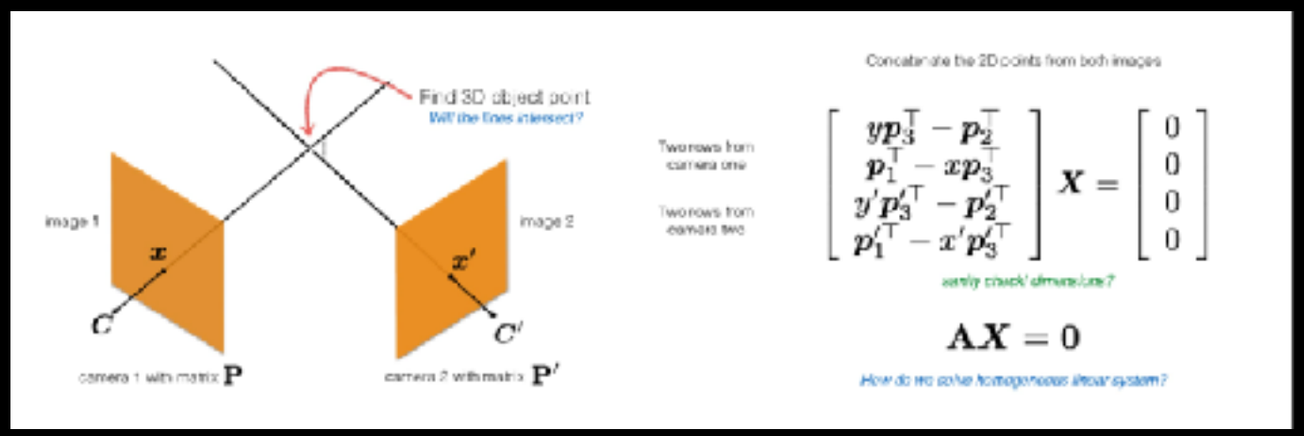
에 가까우면 됨!

Depth Estimation

1. Triangulation



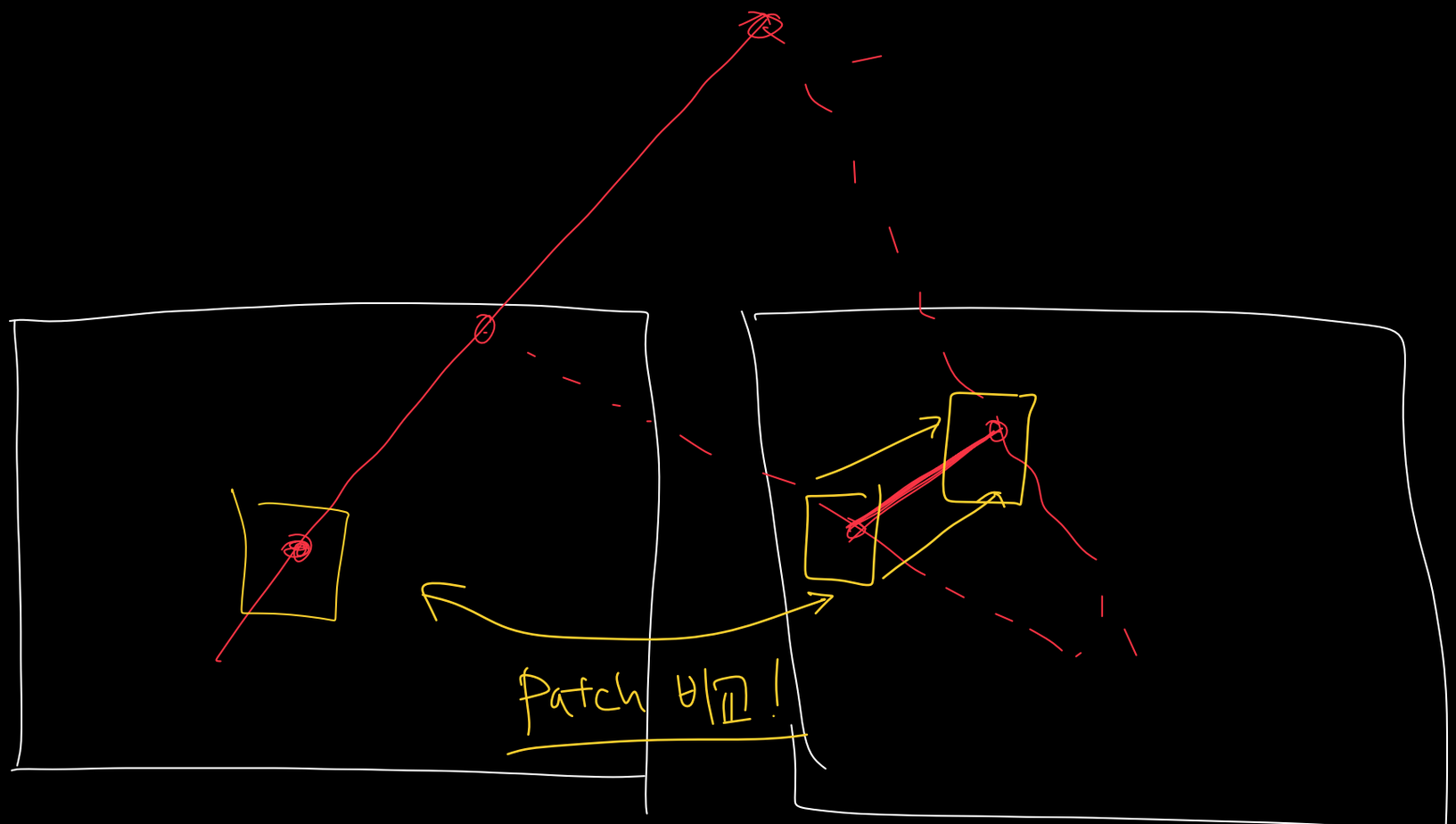




조건 ! 점 매칭이 되어야 계산 가능!

Depth Estimation

2. Patch matching

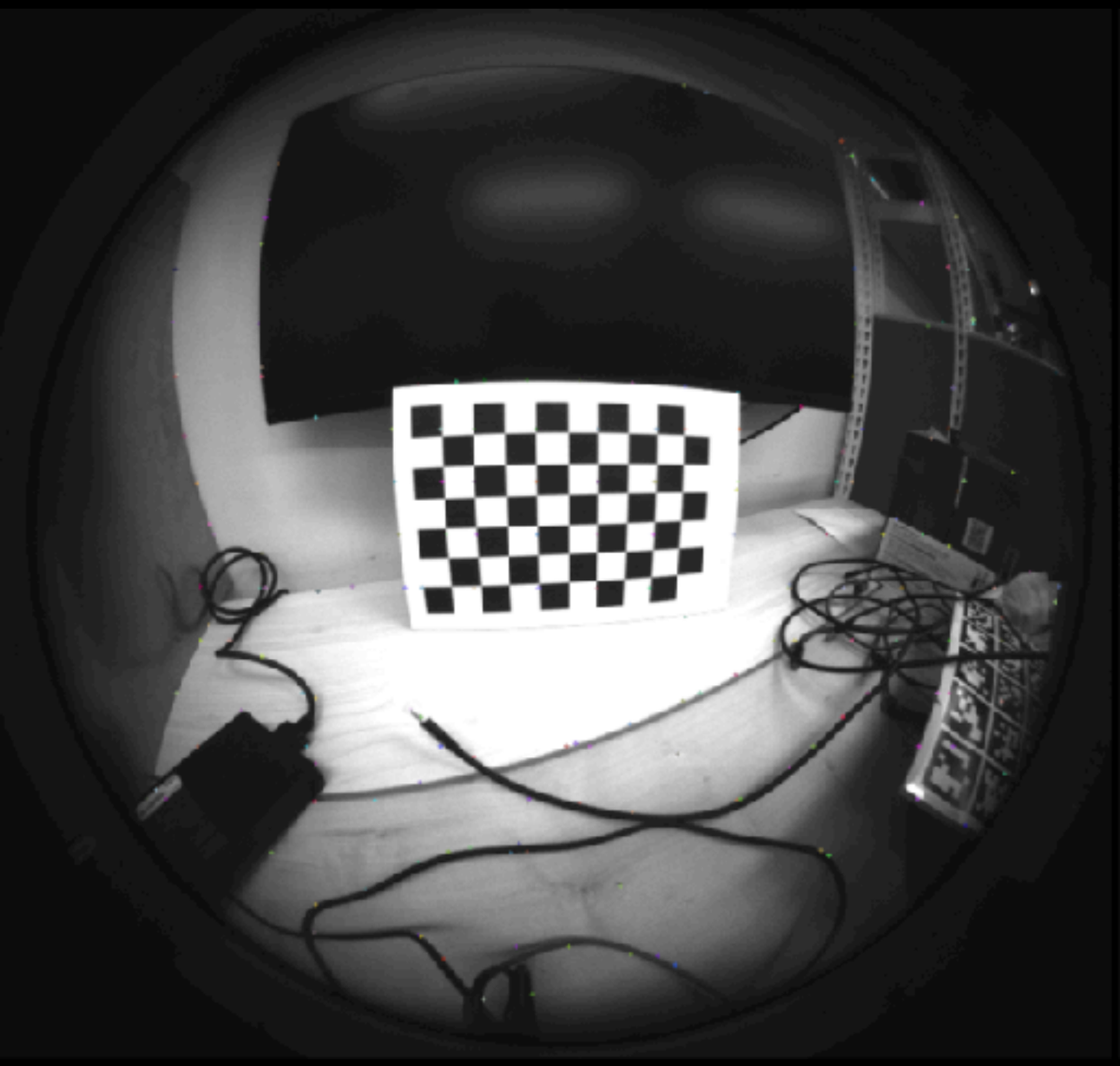


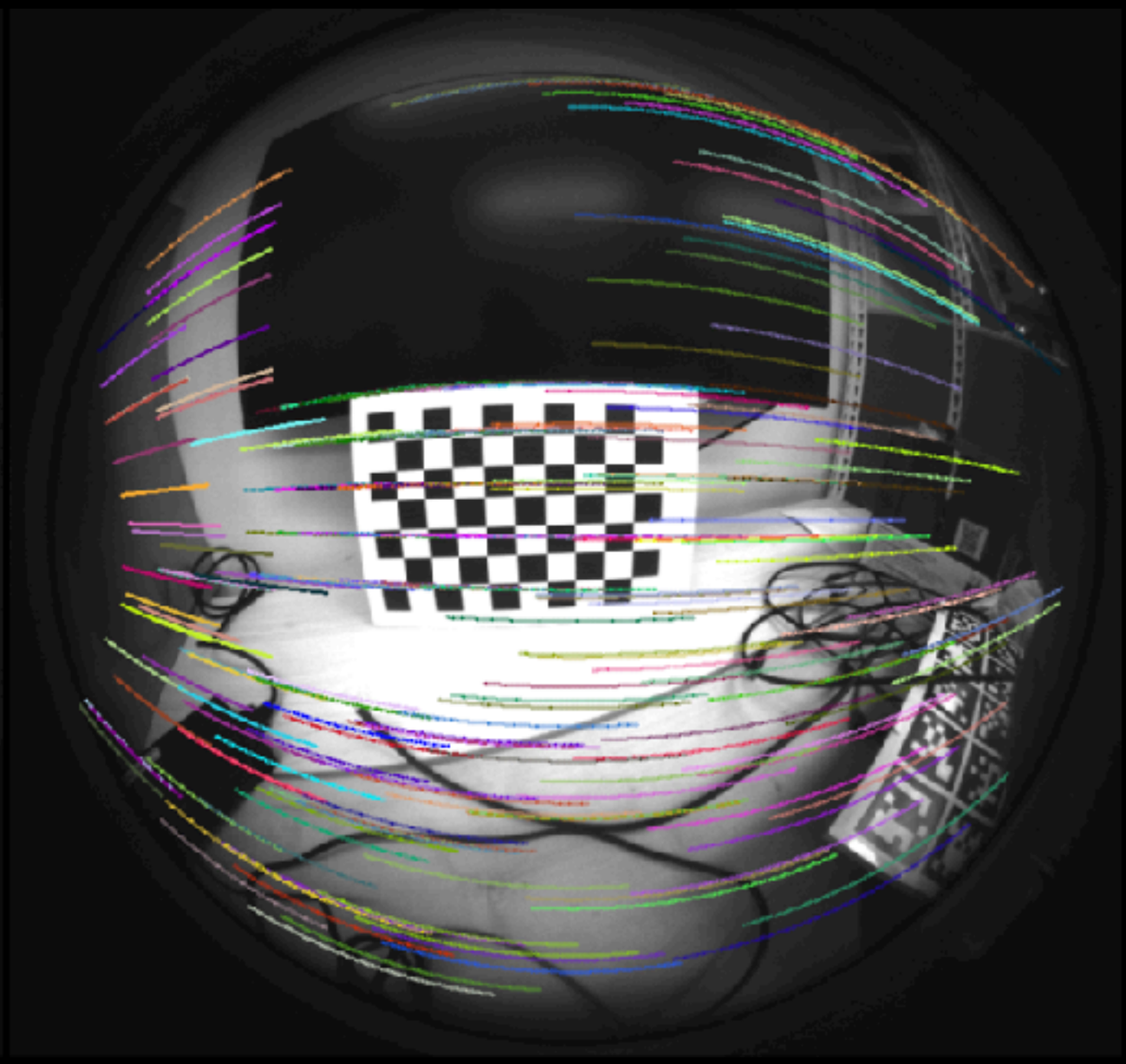
⇒ matching 되면 해당 점 기반으로

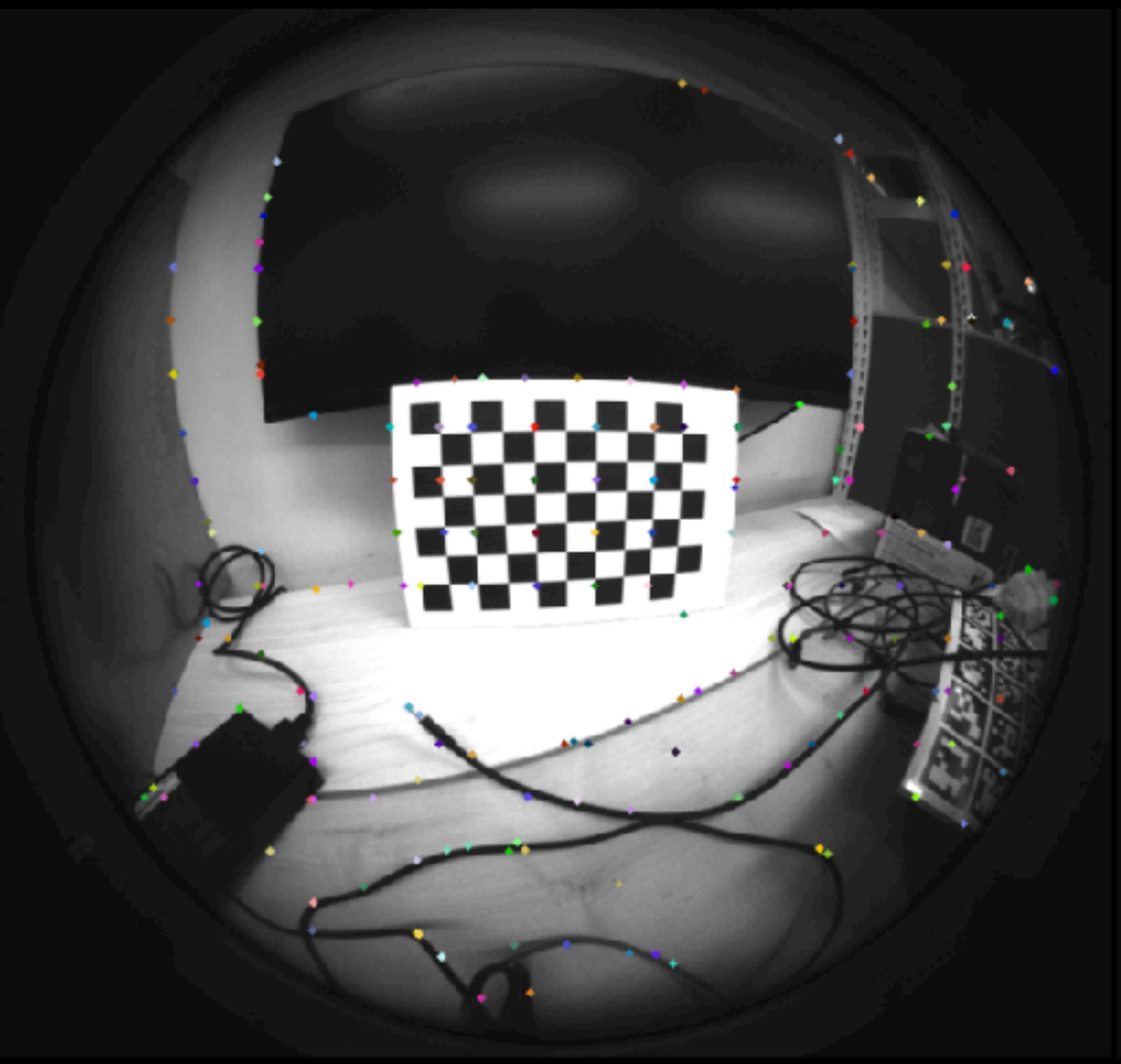
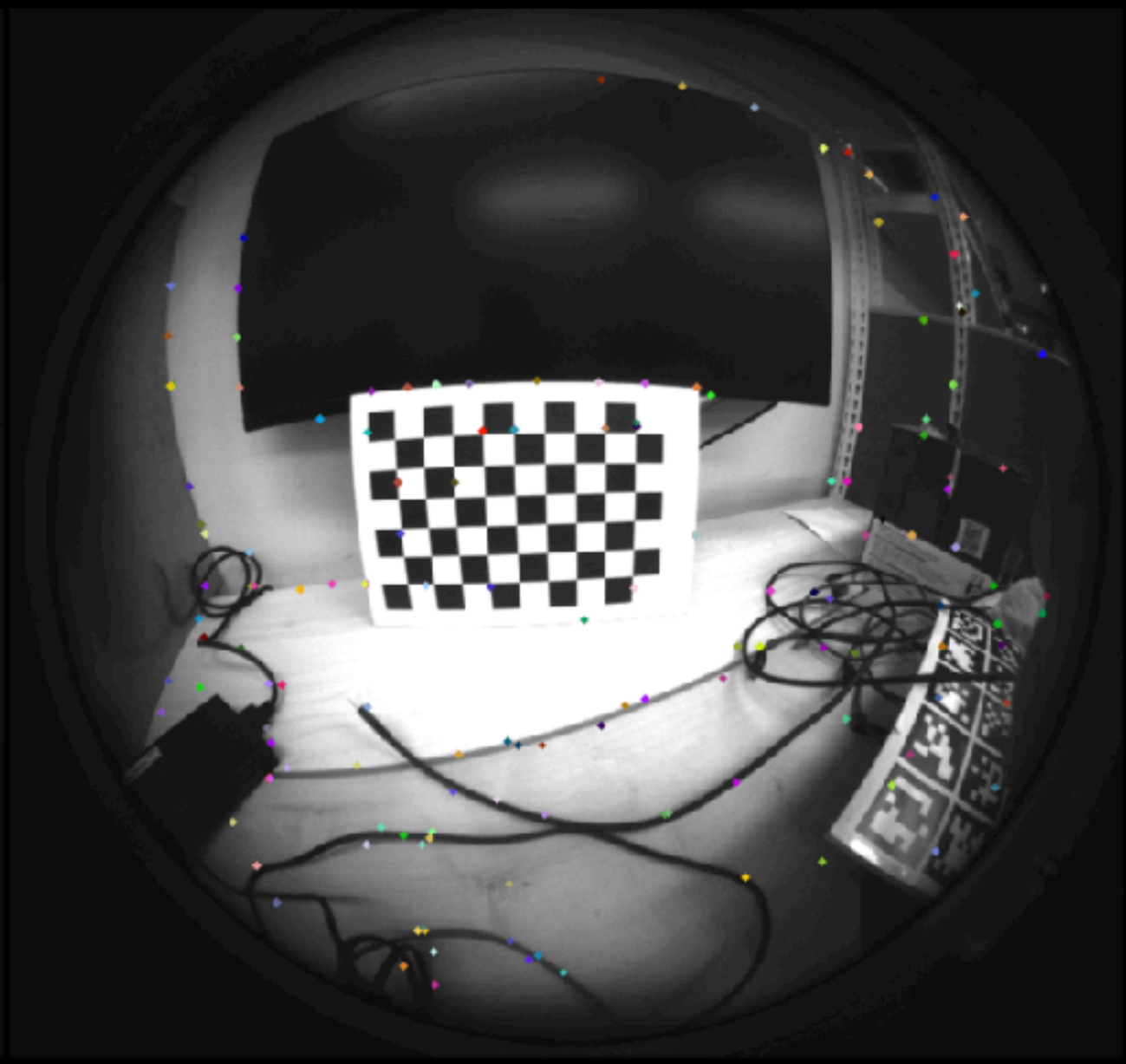
depth estimation 가능!

Depth Estimation

2. Patch matching - 실습





Depth Estimation

2. Patch matching - 실습