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# **Automatic light and camera exposure control for structured-light based 3D scanner**

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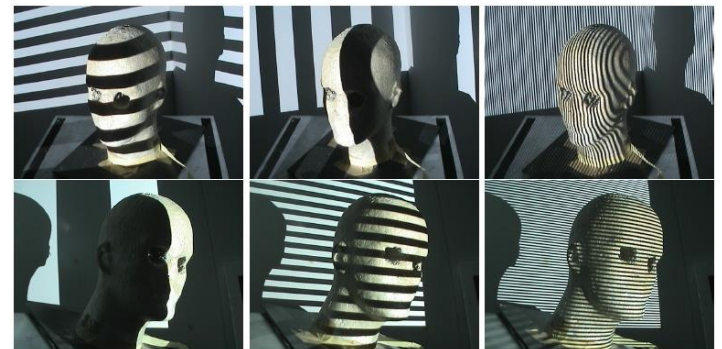
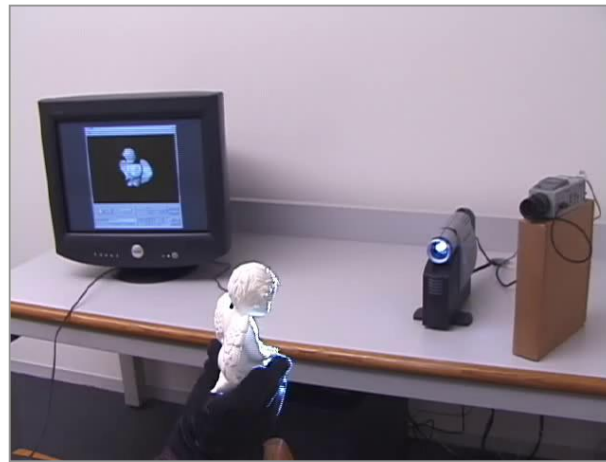
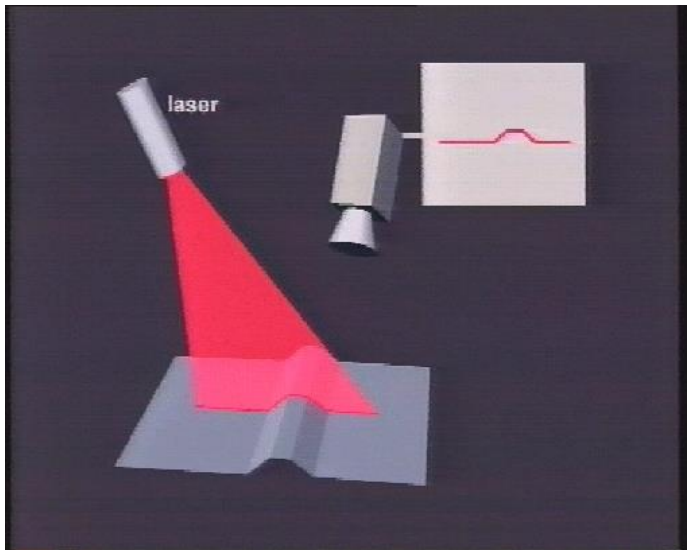
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- **Introduction**
- **Related Work**
- **Overview of our approach**
- **Proposed Process**
- **Experimental Result**
- **Conclusion**

# Related Work

- **Active Stereo**

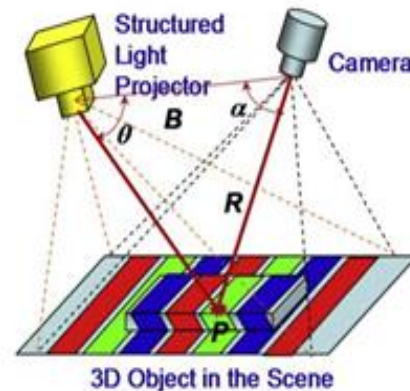
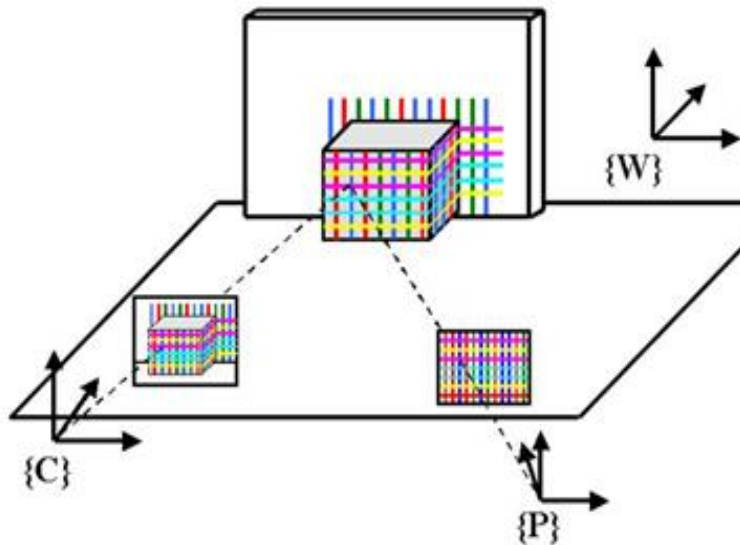
- ✓ Active manipulation of scene
- ✓ Project light pattern on object
- ✓ Observe geometry of pattern via camera → 3D geometry



# Related Work

- **Active Stereo: Light Spot Projection**

- ✓ We project a series of structured light images onto the scene.
- ✓ The structured lighting enables us to uniquely code each scene pixel.
- ✓ We decode the set of projected intensities at each pixel to give it a unique label.



$$R = B \frac{\sin(\theta)}{\sin(\alpha + \theta)}$$

W: World C: Camera P: Projector

# Introduction

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- **We need a light and camera exposure control for structured light based 3D scanner because**
  - **It is difficult to detect corresponding points in external (bright or dark) environment**
  - **Semiconductor light emitting device has life span problem**
  - **Semiconductor light emitting device has problem with generating maximum light**
- Therefore, we propose an exposure and light controller with using light sensor to detect outer illumination using white-light to have maximum illumination and to increase the life of the source

# Previous Work

- Structured light uses additional energy to obtain 3-D information (refer to as active trigonometry) using camera (single or stereo) and one projection device
  - ✓ Scharstein, D., Szeliski, R. “High-accuracy stereo depth maps using structured light” IEEE Conference on Computer Vision and Pattern Recognition, 2003
    - However, there is no consideration on external light environment
  - ✓ Mobit Gupta, Qi Yin, and Shree K. Nayar, “Structured Light in Sunlight”, The IEEE International Conference on Computer Vision (ICCV), 2013
    - uses concentrating light source to get information but it requires excessive amount of measurement

# Related Work

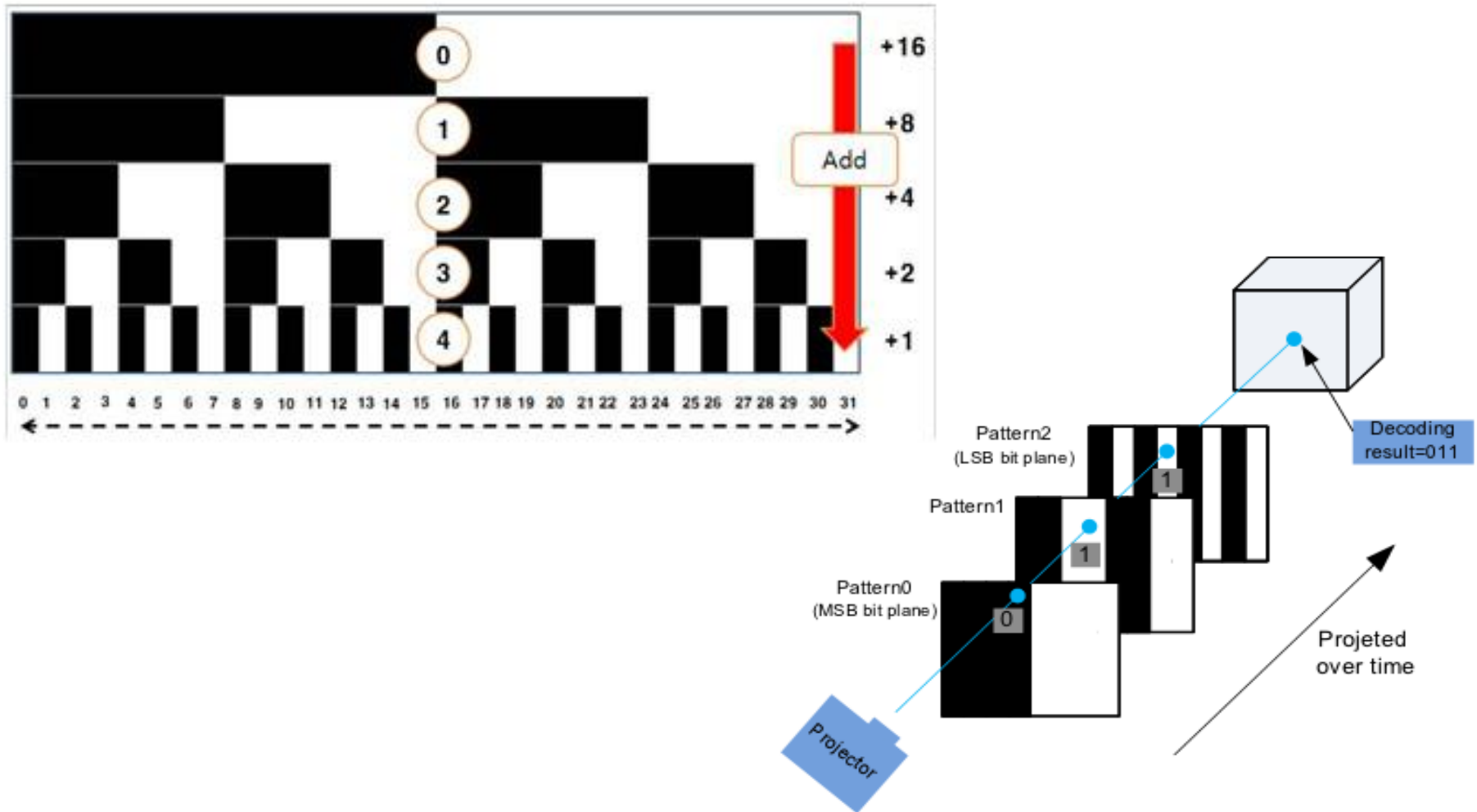
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- **Time-multiplexing coding [1]**
- Projecting over time consisting of a series of patterns to distinguish code word
  - Slow because of multiple patterns
  - Resilient to complicated environment
  - Can get Accurate disparity information

[1] Scharstein, D., Szeliski, R. High-accuracy stereo depth maps using structured light” IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2003

# Related Work

- Time-multiplexing coding





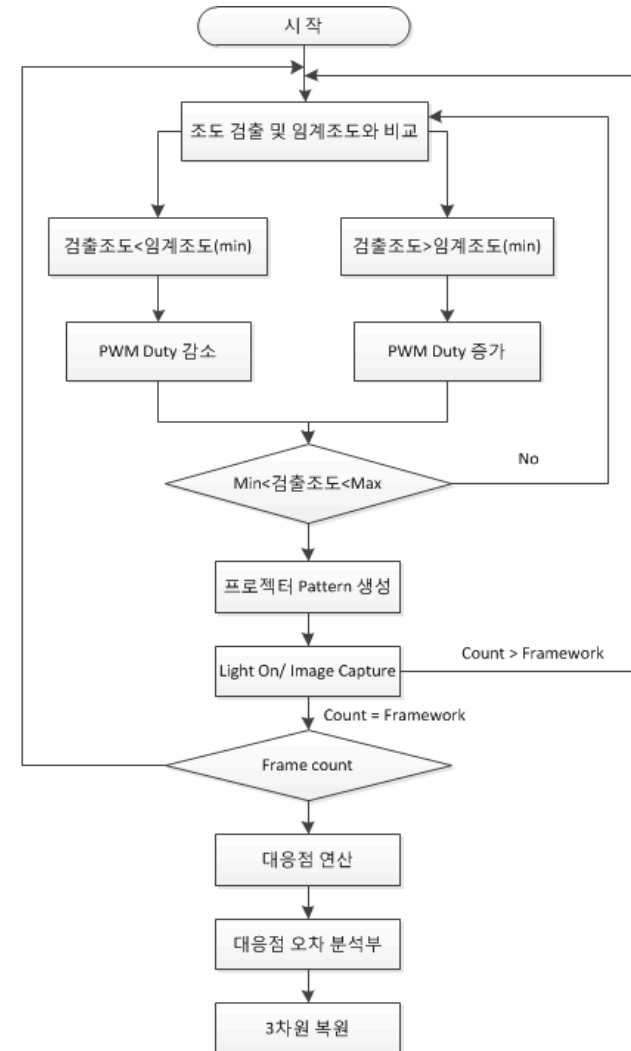
# Related Work

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- **These Structured-light based 3D scanner**
  - **uses semiconductor light emitting device**
  - **Detects pixel corresponding points get 3D data**
  - **Easy to control light strength**
  
- **However, we need to consider external light environment because**
  - **Blurring phenomenon can be exist in dark environment**
  - **We cannot get maximum light intensity and get enough corresponding points in bright environment**
  - **Life span can be shorten**

# Proposed Work

- Overall Proposed method



# Proposed Work

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**While Error  $>$  threshold & caused by discontinuity or shadow  
(Control PWM duty and exposure)**

**If external illuminance  $<$  minimum threshold illuminance**

- It means external environment is dark.
- Blurring phenomenon can be exist.
- Decrease PWM duty and increase exposure time.

**Else external illuminance  $>$  maximum threshold illuminance**

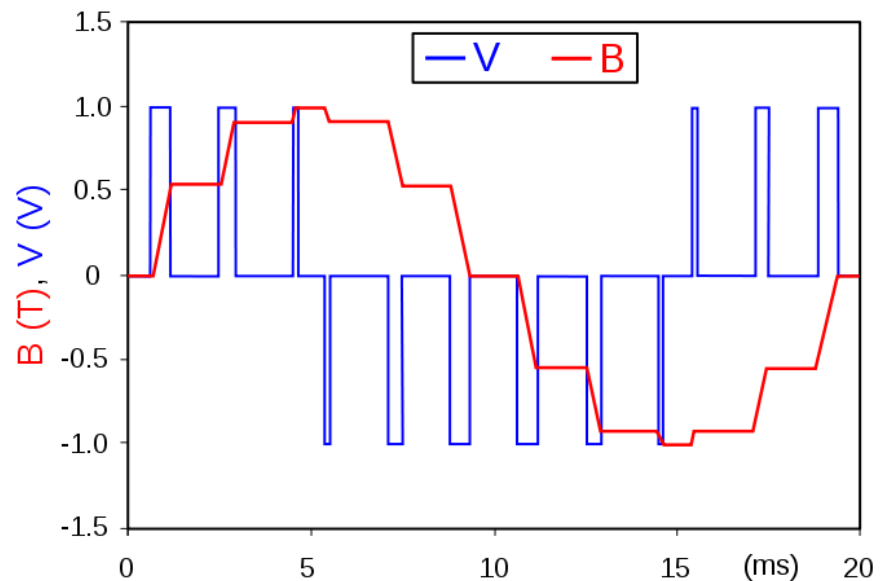
- It means external environment is bright.
- It is hard to get clear patterns.
- Increase PWM duty and decrease exposure time.

**Else Projecting pattern and calculating corresponding points**

# Proposed Work

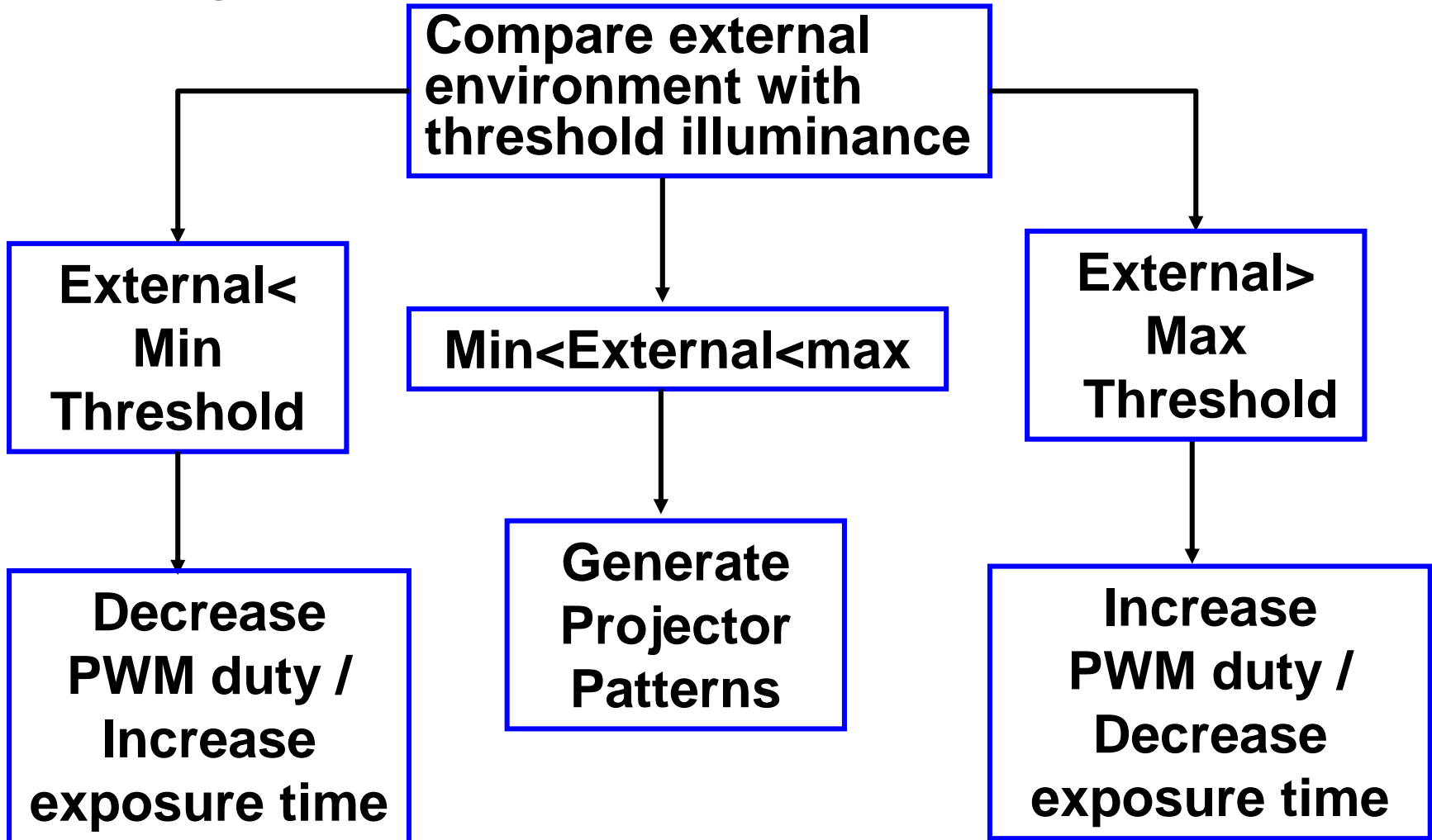
- **PWM**

- **Digital output of the processor which controls analog circuit**
- **Controlling method which changes width of the pulse and frequency**
- **Does not require any DAC and minimizing noise by continuing to keep digital signal**



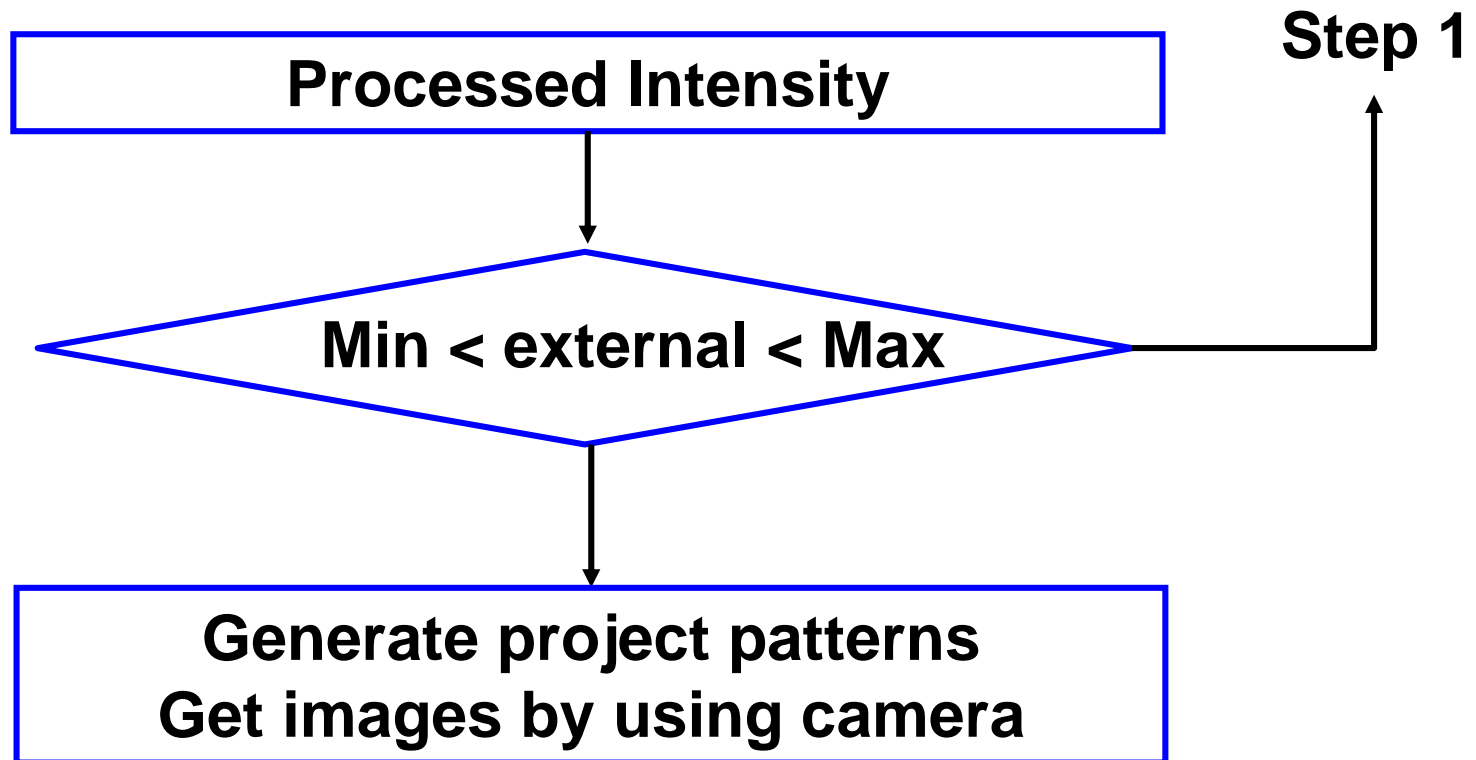
# Proposed Work

**Step 1: Controlling PWM duty and exposure time after comparing external environment with threshold illuminance**



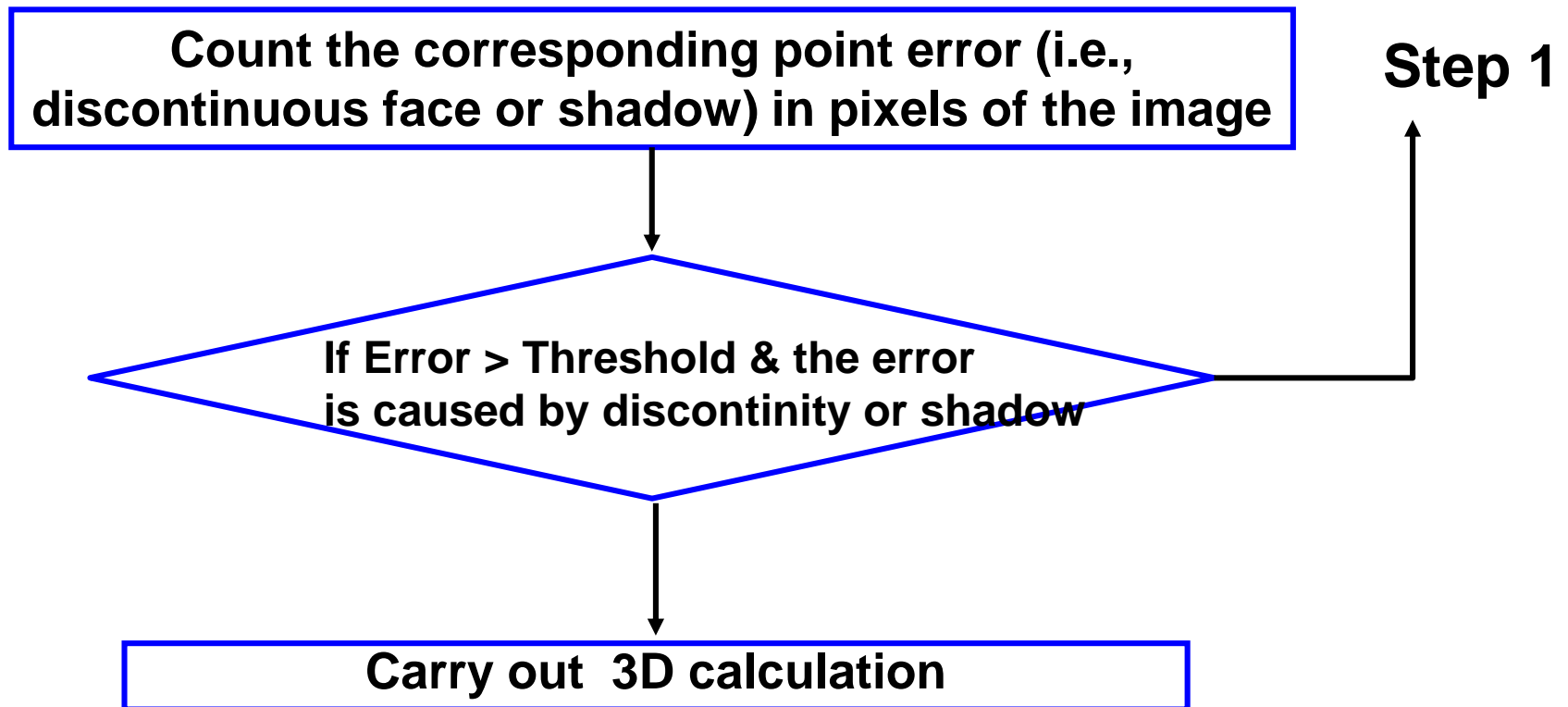
# Proposed Work

**Step 1. If  $\text{Min} < \text{external} < \text{Max}$ , then projecting pattern and calculating corresponding points**



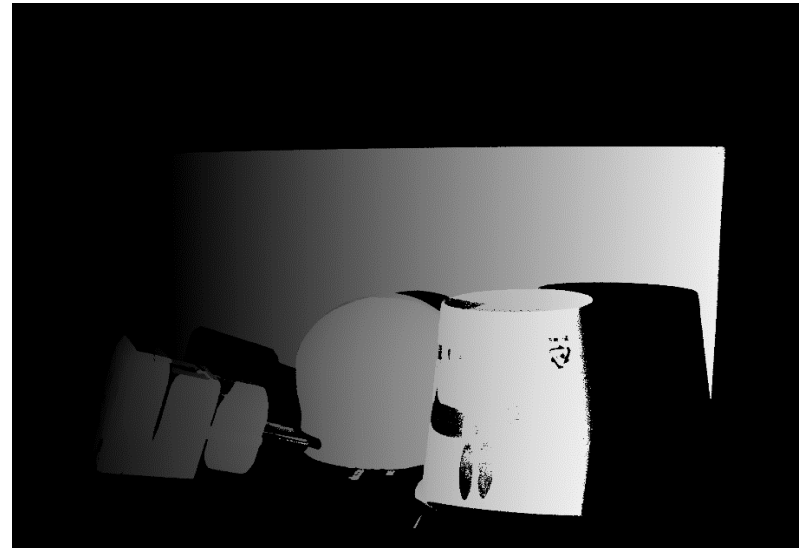
# Proposed Work

## Step 2. Error Analysis after computing corresponding point



# Experimental Result

- **When dark external environment**

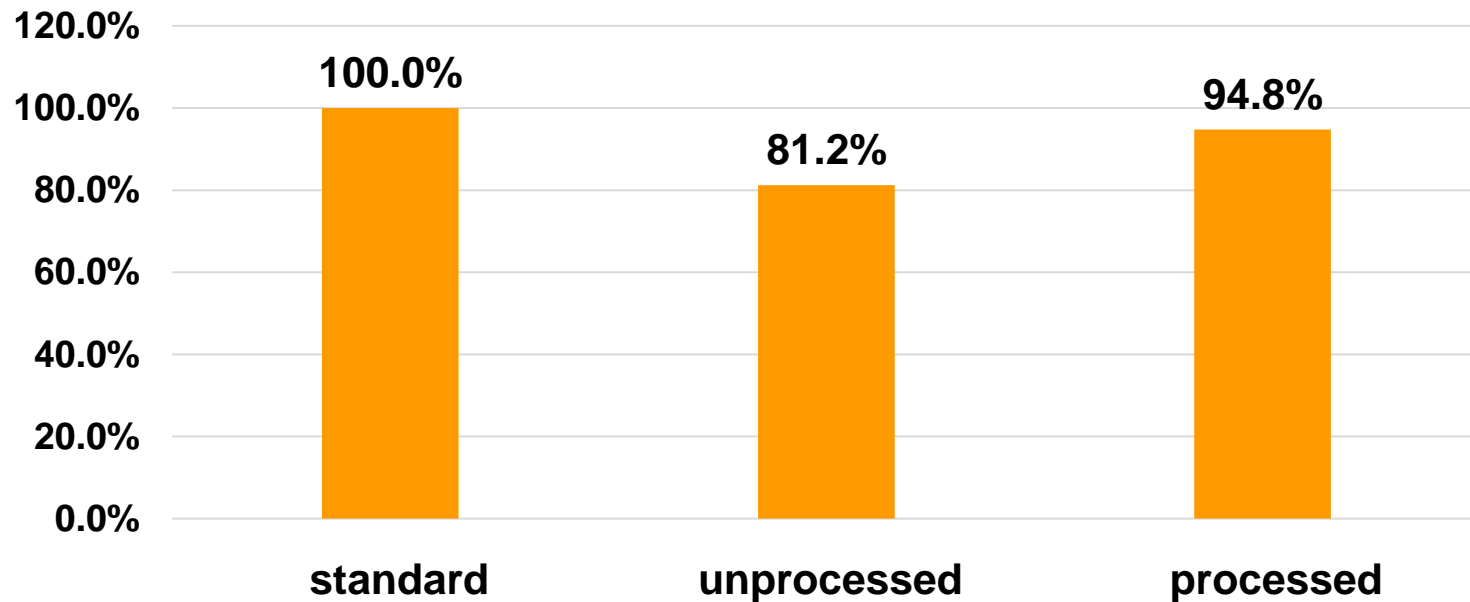




# Experimental Result

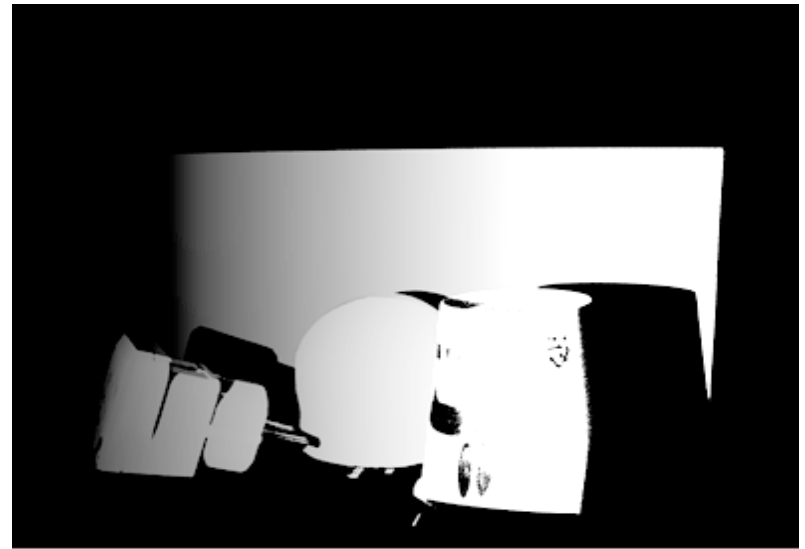
- **When dark external environment**

**Calculation result of the corresponding point  
in dark environment**



# Experimental Result

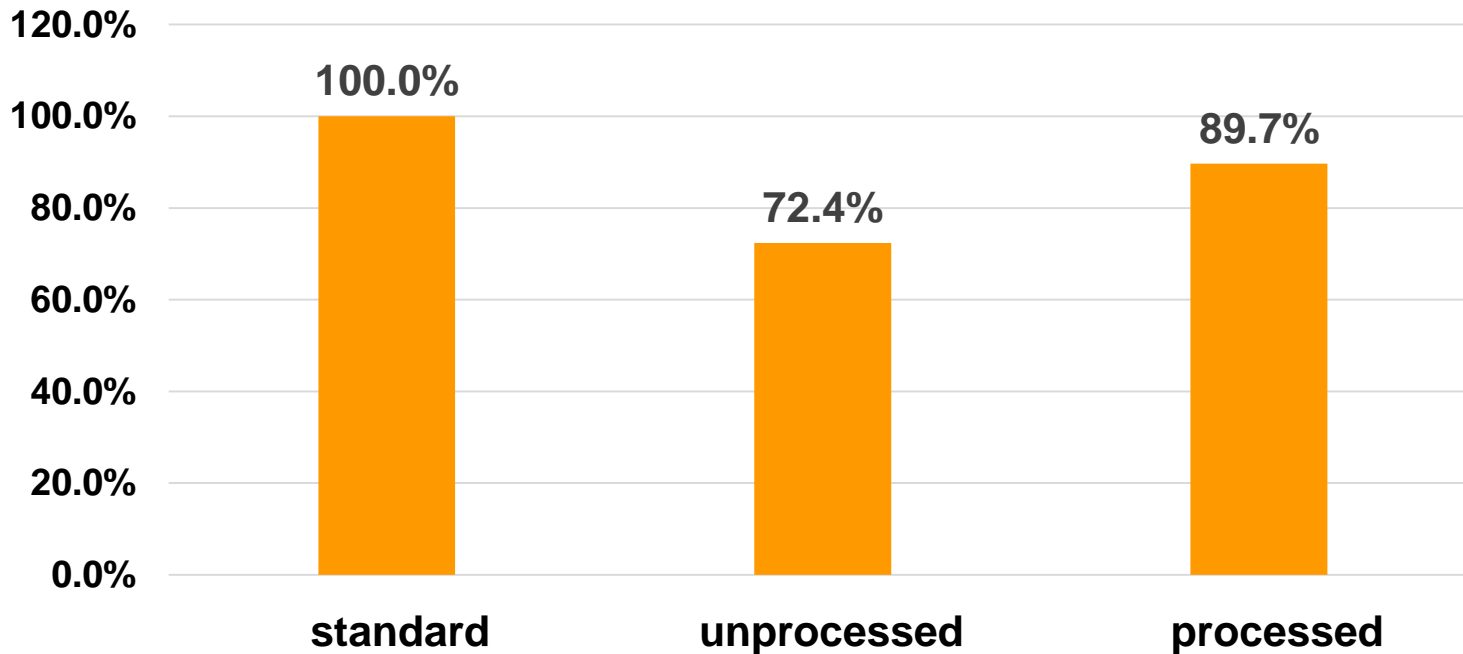
- **When bright external environment**



# Experimental Result

- **When bright external environment**

**Calculation result of the corresponding point  
in bright environment**



# Conclusion

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- **Light and camera exposure control should be needed for detecting corresponding points.**
- **Previous methods did not consider external environment with dark and bright environment simultaneously.**
- **By controlling light and camera exposure, reliability of corresponding points calculation was increased.  
( In bright environment: 17.3% In dark environment: 13.6% )**