Sensitivity Evaluation of Embedded Code Detection in Imperceptible Structured Light Sensing

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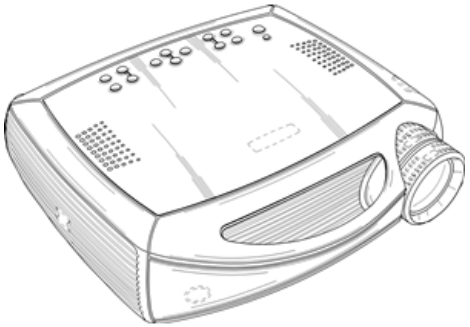
Introduction & Motivation

- **Projector-Camera Systems in Robotics**
  - *Augmented Reality*
  - *Human-Robot Interaction*
  - *Some Other Applications*
- **Imperceptible Structured Light Sensing (ISL)**



Display Device

Show Video Content

3D Sensor

Derive the 3D information

Introduction & Motivation

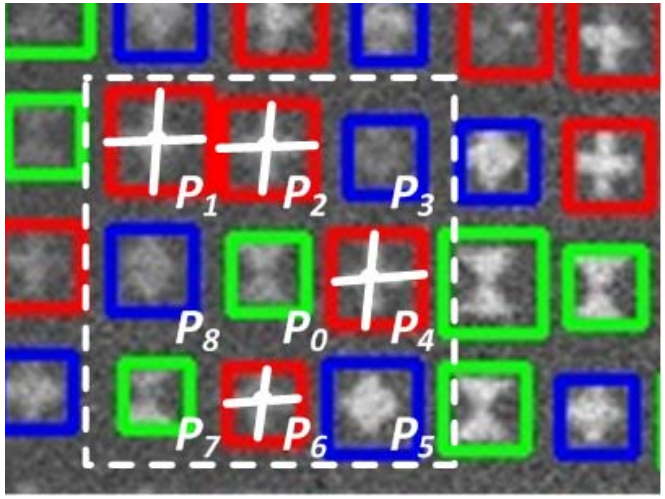
J. Dai and R. Chung, On Making Projector both a Display Device and a 3D Sensor, In Proc. of ISVC12, pages 654-664, 2012.

Coding

- **specifically designed shapes**
- **large hamming distance**

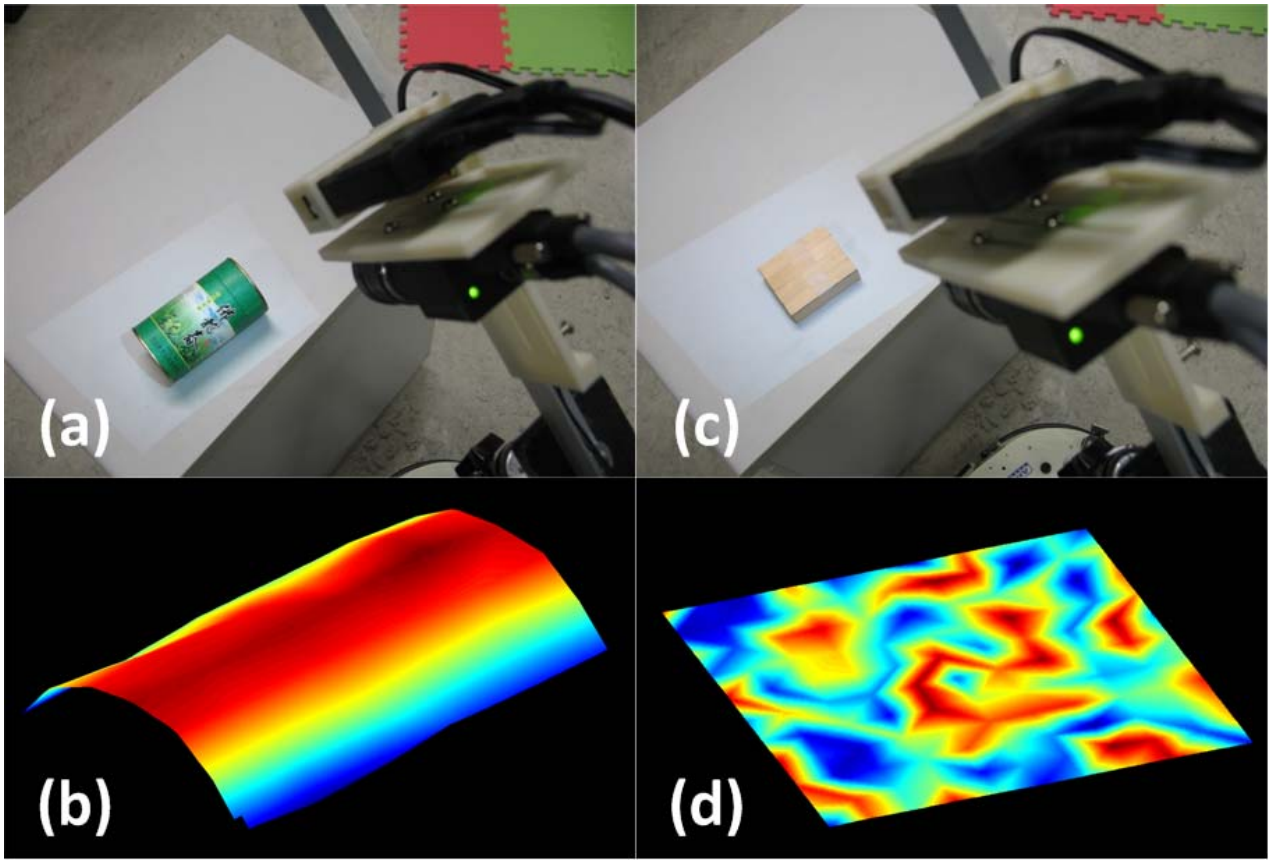
Decoding

- **Pre-trained shape detector**



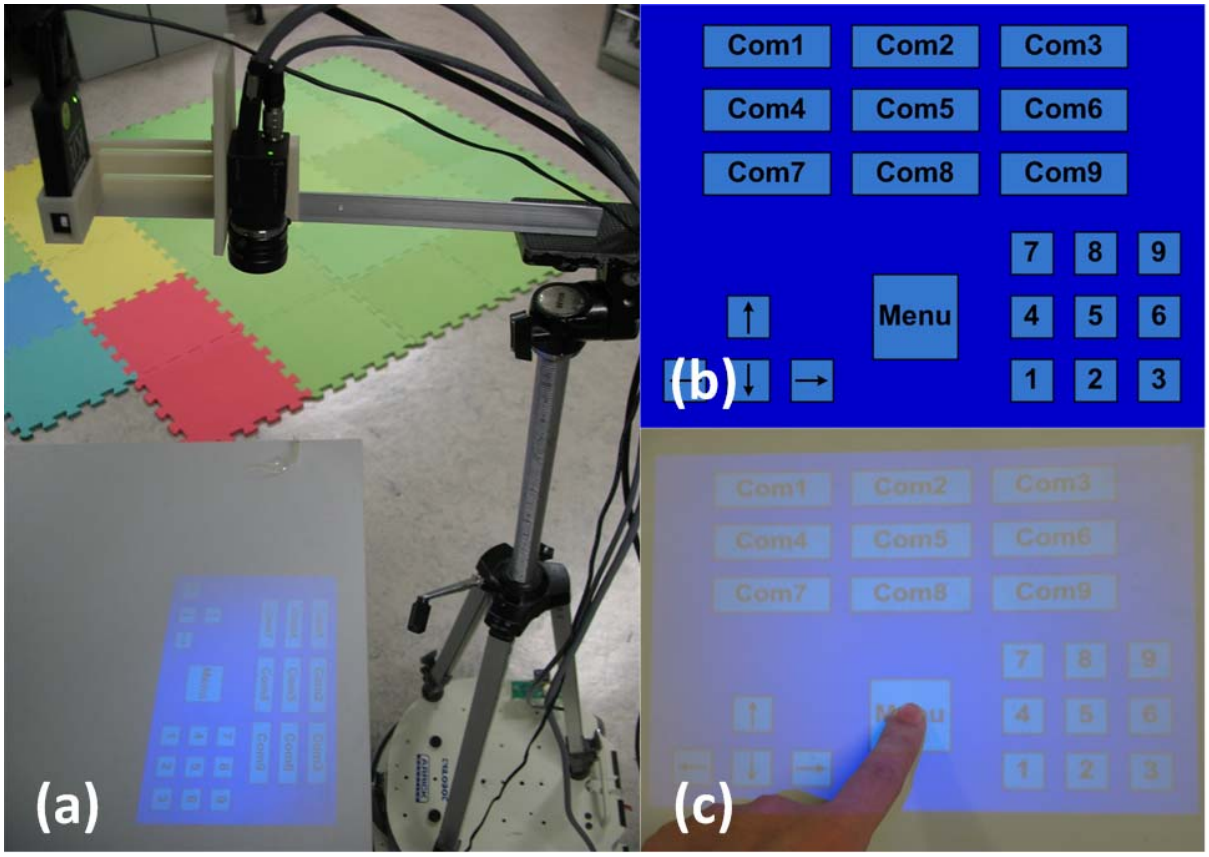
Robotic Applications –
Sensing Surrounding Environment

J. Dai and R. Chung, Embedding Imperceptible Codes into Video Projection and Applications in Robotics, In Proc. of IROS12, pages 4399-4404, 2012.

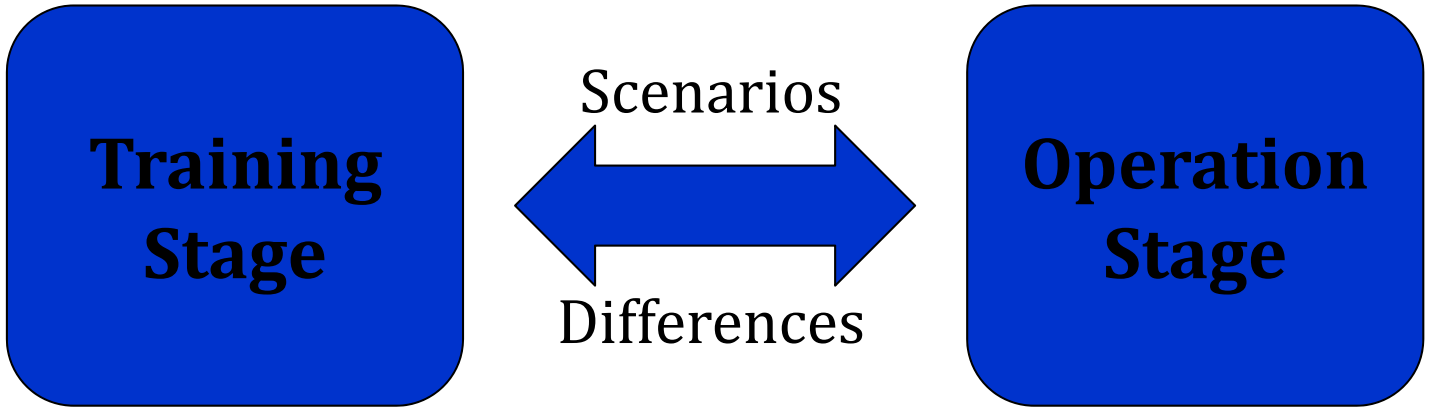


Robotic Applications –
Natural Human-Robot Interaction

J. Dai and R. Chung, Embedding Imperceptible Codes into Video Projection and Applications in Robotics, In Proc. of IROS12, pages 4399-4404, 2012.



Sensitivity Evaluation



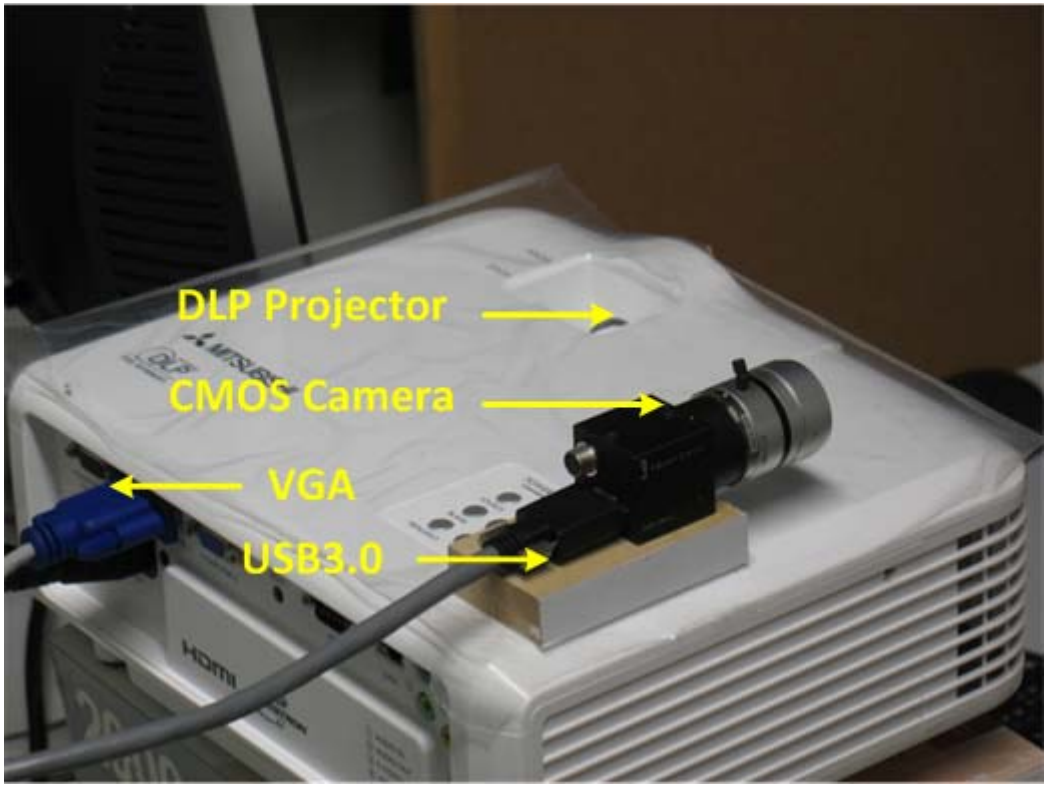
Sensor-Object Localization

Projection Surfaces

Surrounding Environment

Hardware Platforms

System Setup



PROCAMS-A

PROCAMS-B

Hardware Configuration

	PROCAMS-A	PROCAMS-B
Projector	Mitsubishi EX240U Projector 1024 * 768	TI DLP Pico Projector Development Kit 2 640 * 480
Camera	Point Grey Flea3 FL3-U3-13S2C 1328 * 1048@120fps	Point Grey Flea3 FL3-FW-03S1C 648 * 488@120fps
Lens	Myutron FV1520 f15mm	Myutron FV0622 f6mm lens
Pro-PC	VGA	HDMI
Cam-PC	IEEE-1394	USB 3.0

Benchmark

Training Sample Collection Scenario

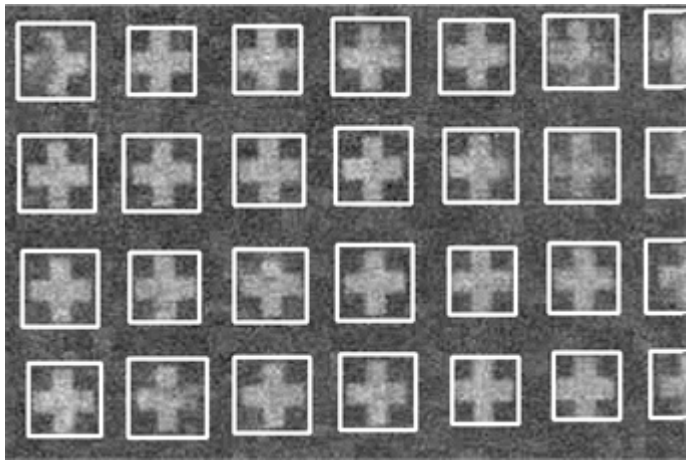
Distance	*800mm*	500mm	1200mm	1600mm		
Orientation	0°	10°	20°	30°	40°	50°
Shape	*Planar*	Convex	Concave	Free-Form		
Texture	*White*	Green	Cork	Poster		
PROCAMS	*A*	B				

When the scenarios of training stage and operation stage are almost the same, about 95% primitive shapes can be detected and identified correctly.

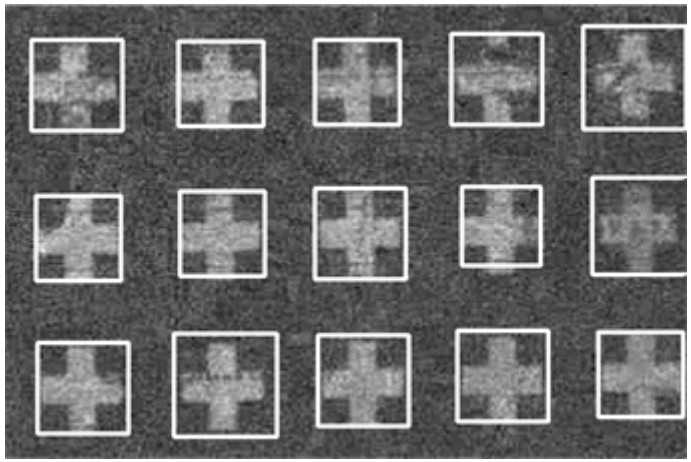
Sensitivity Evaluation: Working Distance

In training data collection:
Working Distance: 800mm

500mm



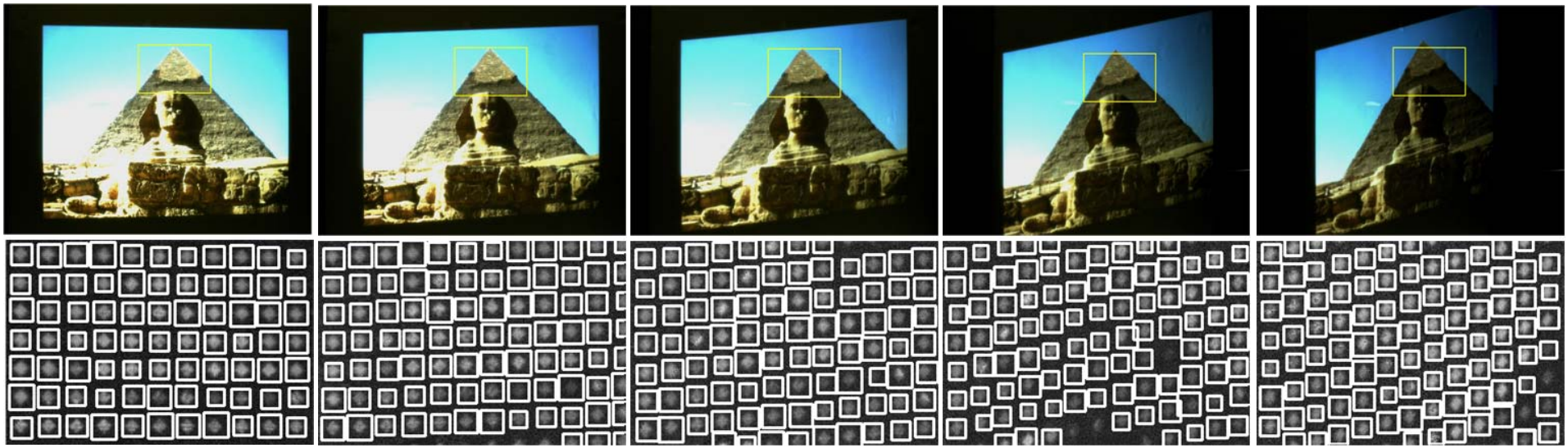
1200mm



1600mm

Sensitivity Evaluation: Projection Surface Orientation

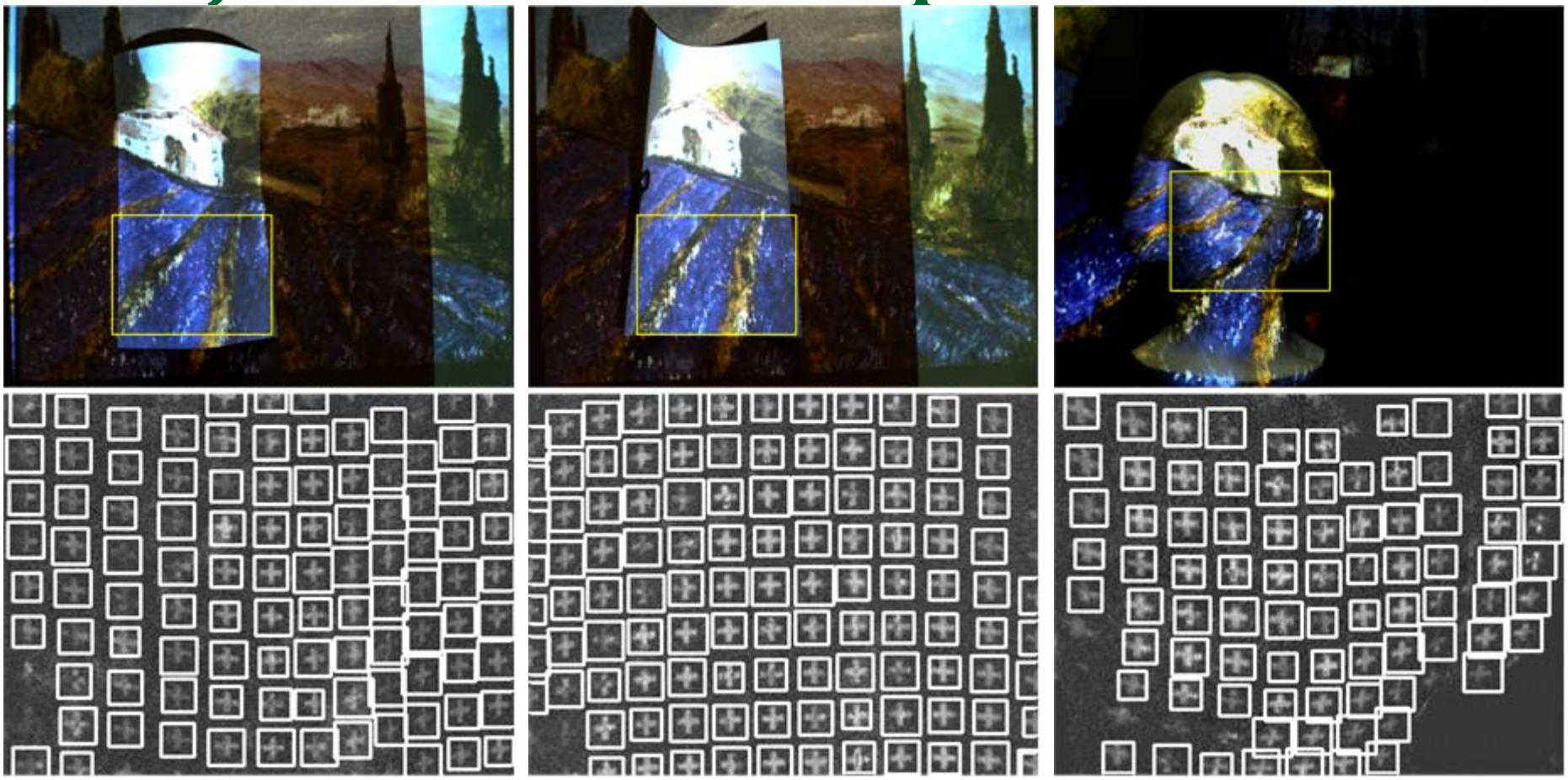
In training data collection:
Surface Orientation: $\theta = 0^{\circ}$



$\boldsymbol{\theta = 10^{\circ}}$ $\boldsymbol{\theta = 20^{\circ}}$ $\boldsymbol{\theta = 30^{\circ}}$ $\boldsymbol{\theta = 40^{\circ}}$ $\boldsymbol{\theta = 50^{\circ}}$

Sensitivity Evaluation: Projection Surface Shape

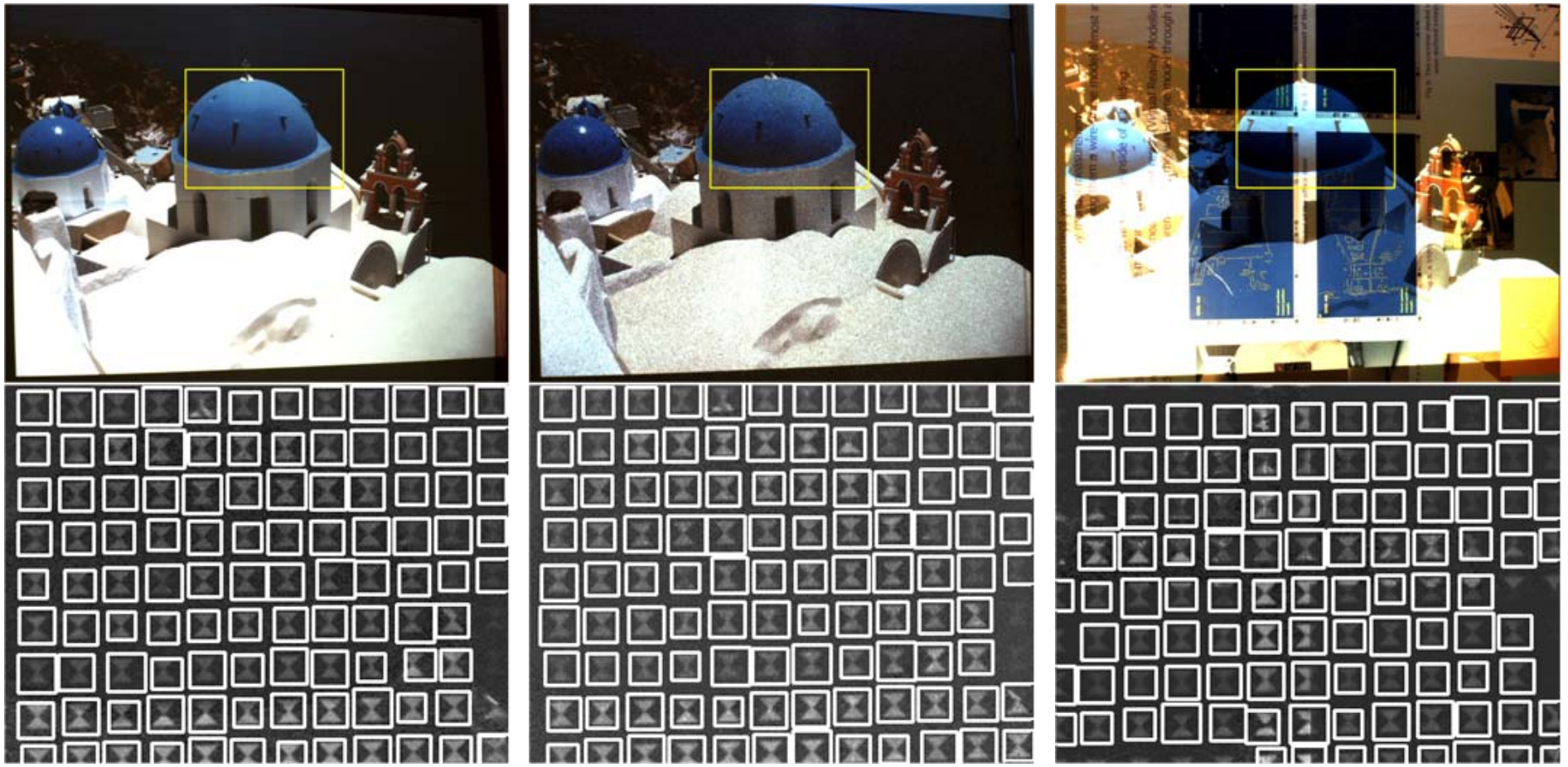
In training data collection:
Projection Surface: Planar



Convex Surface | Concave Surface | Plaster Statue

Sensitivity Evaluation: Projection Surface Texture

In training data collection:
Surface Texture: White Paper

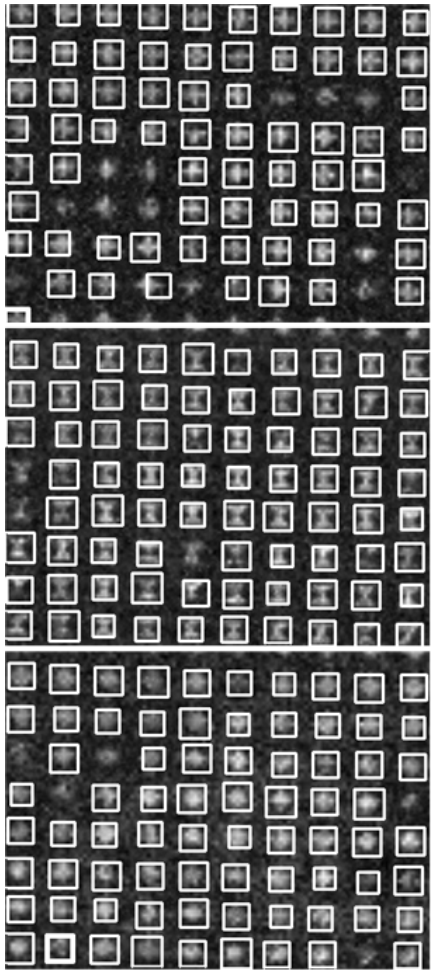


Green Paper | Cork Board | Poster

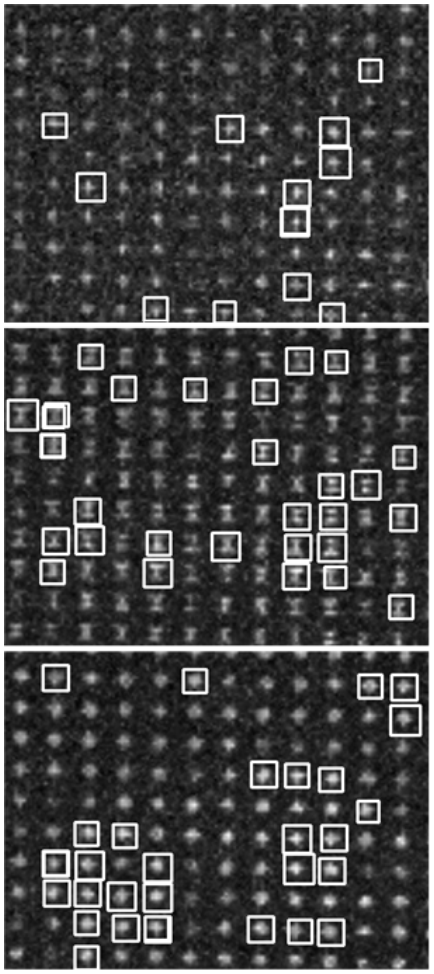
Sensitivity Evaluation: PROCAMS

In training data collection:
PROCAMS: PROCAMS-A

Captured Image



Cropped Patt.



Resized Patt.

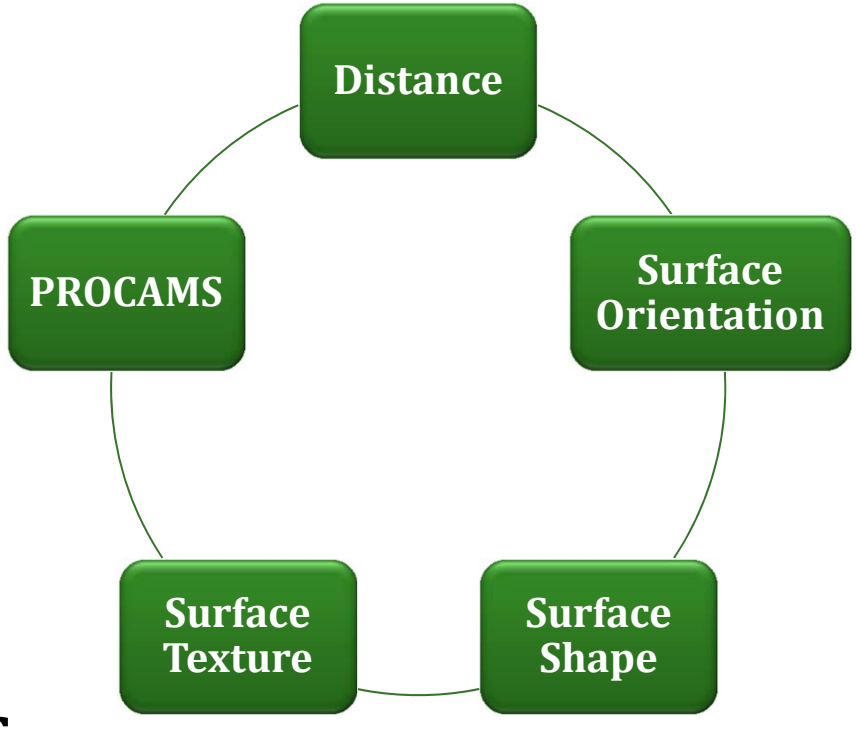
Sensitivity Evaluation: Conclusion

Condition	Hits (%)	Missed (%)	False (%)	Ed (pixel)
Benchmark	94.53	3.95	1.52	1.632
Distance (500mm)	86.21	11.63	2.16	1.814
Orientation (50 degree)	85.91	12.03	2.06	2.728
Surface (Plaster Statue)	84.81	13.33	1.86	2.028
Texture (Poster)	91.74	6.63	1.63	2.024
PROCAMS (Cropped Pattern)	80.23	14.43	5.34	3.028

For more detailed sensitivity evaluation results, please refer to the paper

Conclusion and Future Works

Sensitivity evaluation of embedded code detection in imperceptible structured light sensing.



Future Works

- *Extending imperceptible structured light sensing to a variety of robotic applications.*

THANK YOU!!

If you have any questions, please contact

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