
Robot Vision: Depth sensing

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Outline

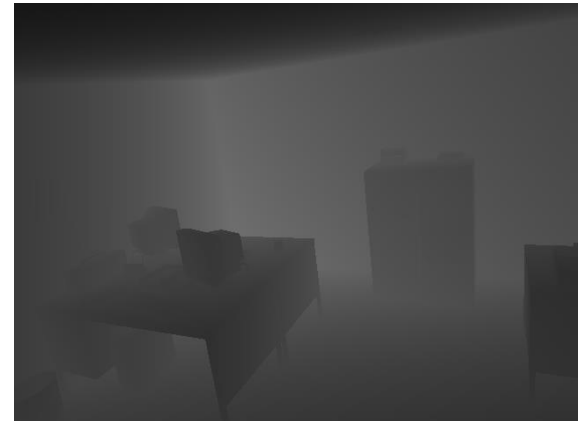
- Depth cameras
 - Coded light
 - Kinect style depth cameras
 - TOF cameras

Depth cameras - Overview

- Depth cameras or RGBD cameras directly output an RGB image and a depth image
- Principles:
 - Stereo cameras with onboard processing
 - DJI Guidance, Roboception, Perceptin
 - Structured Light
 - Coded light – Projector-camera system
 - Random patterns – Stereo system with active lighting
 - Kinect-style methods – Projector-camera system with fixed random projection
 - TOF cameras – time of flight principle
- Huge importance for mobile robotics



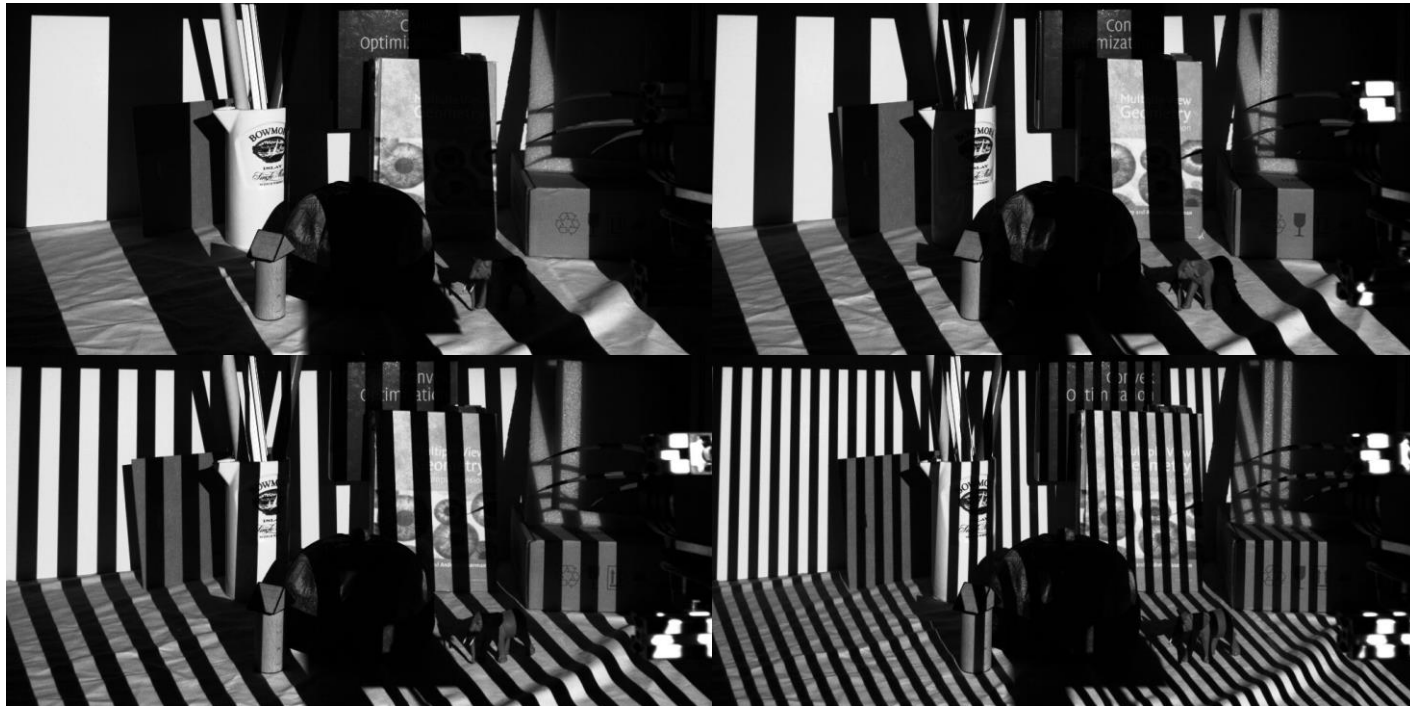
RGB image



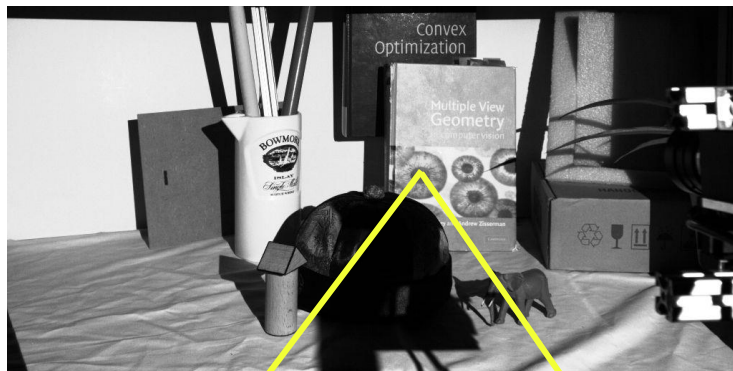
depth image

Coded Light

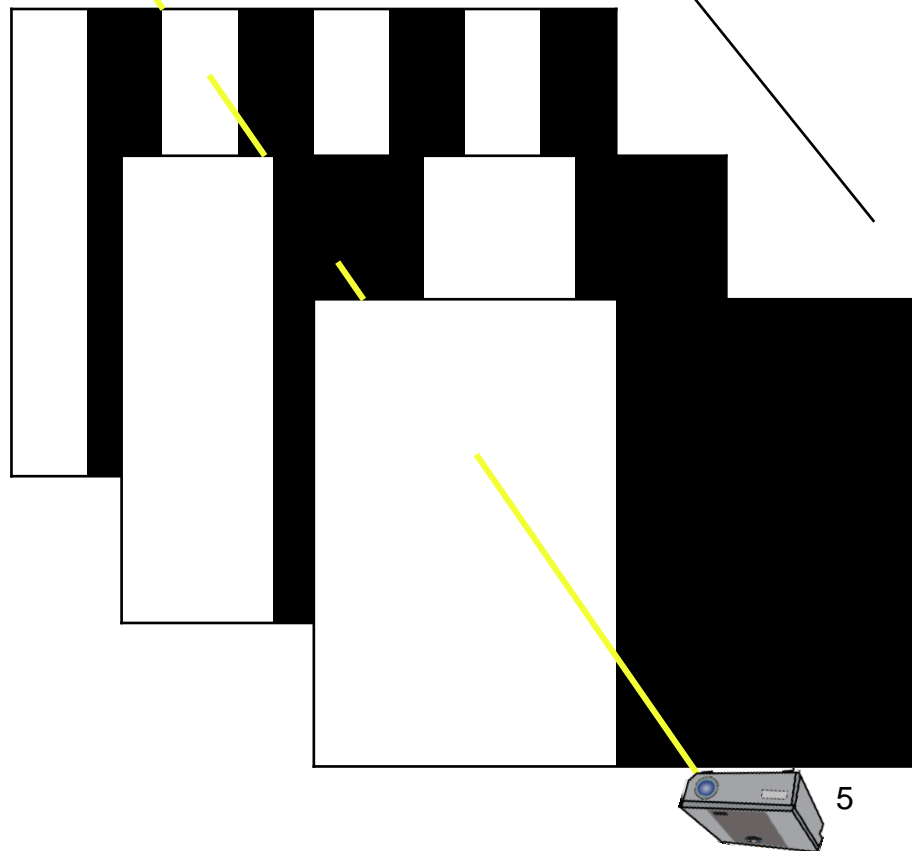
- A projector-camera system where a projector outputs stripe patterns (e.g. binary pattern)
- The pattern solves the correspondence problem in stereo matching
- Projector and camera need to be calibrated
- The stripes are coded and encode directly a unique position of a corresponding pixel in the projector.



Coded light



pattern changed over time

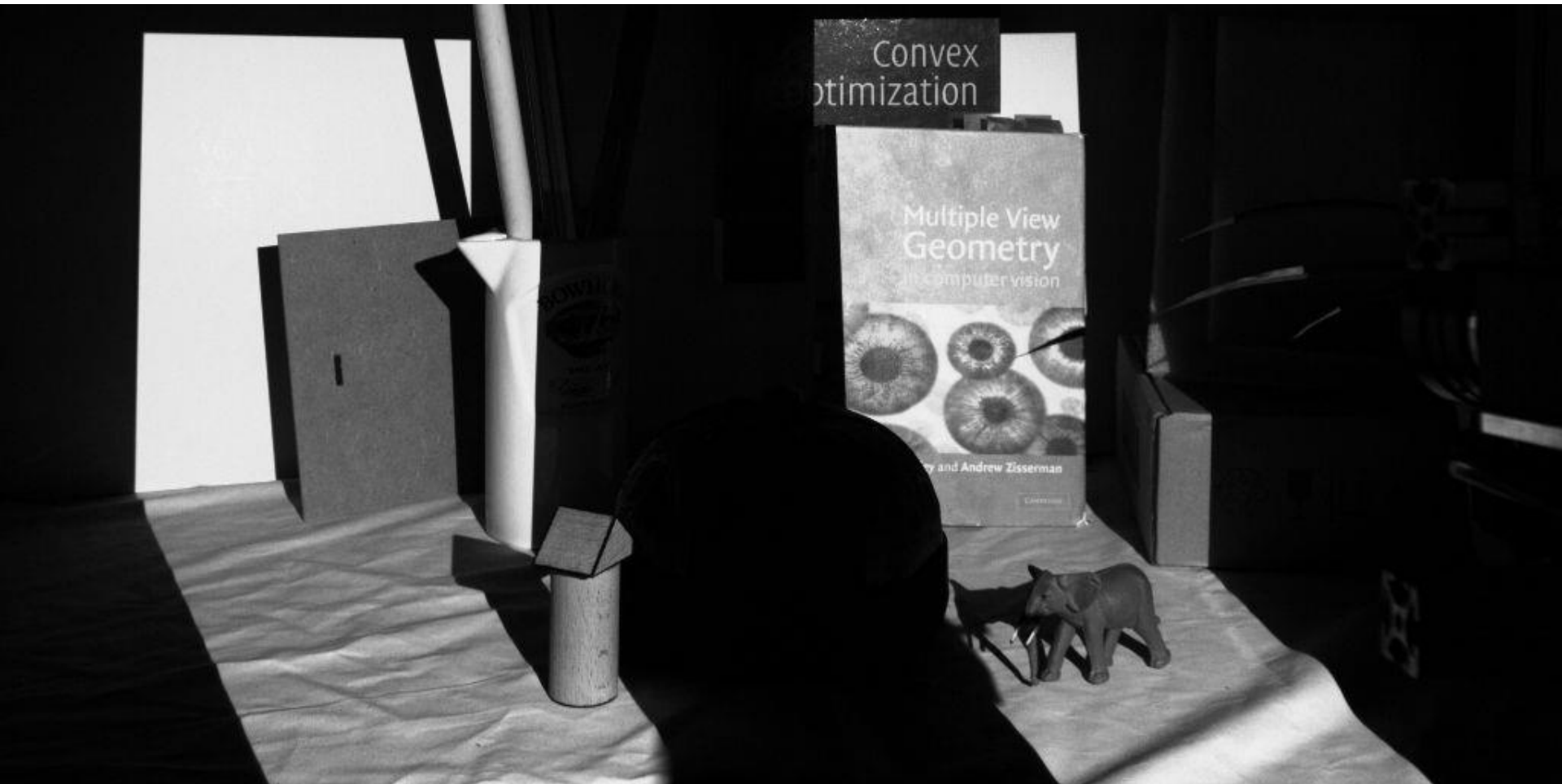


sequence of dark/light pattern defines a code word for a position and thus a unique position in the projector

Coded light



Coded light



Coded light



Coded light



Coded light



Coded light



Random patterns

- Stereo camera system cannot measure depth in textureless/homogeneous areas
- Solution: Project random pattern as texture to ease stereo matching
- Typically this is done in infrared spectrum such that it is not visible for users
- Such a system works in the dark as well

- Example: Intel Realsense
- Standard stereo system (2 calibrated cameras)
- 1 IR projector for stripe-type pattern
- Works outdoors as well, then the pattern is not visible due to strong sunlight (then it just works like standard stereo matching)

Kinect style method

- Kinect is a projector-camera system with onboard depth processing
- Projects a **known** static IR-dot pattern
- Depth is computed from a combination of depth from stereo and depth from focus
- The system also contains an RGB camera
- Sensors is often called a RGBD sensor



image of IR pattern

Time-of-flight cameras

- Does not work on the stereo (triangulation) principle but with time-of-flight principle
- Principle:
 - Sends out NIR light (no spatial coding)
 - Sensor array measures response
 - Distance is measured by measuring time between emitting and receiving the light (pulsed or continuous wave method)
- Typically do not provide synchronized color image but a reflectance image
- Example: PMD Flex (224 x 171px resolution), Creative TOF sensor



Time-of-flight cameras – Continuous wave method

- Camera emits NIR light where amplitude is a sine wave.
- Phase shift is measured between emitted and received light
- Phase shift can be converted into distance

$$d = \frac{c}{4\pi f} \Delta\phi$$

