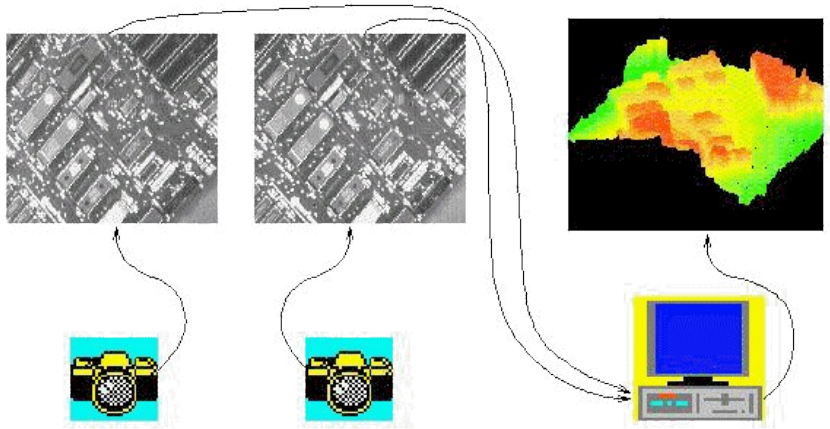
range from cameras

range from cameras

- stereoscopic (3D) camera pairs
- illumination-based
  - spatial domain: structured light
  - temporal domain: time-of-flight imaging

stereoscopic (3D) cameras

- construct pair of cameras
- separate them by some known distance, pointing directions, rotations, etc
- capture pair of images
- identify corresponding points in two images
- trigonometry sufficient to range of each image point



VREX

- CAM-4000

  - uses 2 CCD sensors packaged together
  - synchronized zooming, focus, and Iris/Aperture
  - single or dual channel output

SPECIFICATIONS

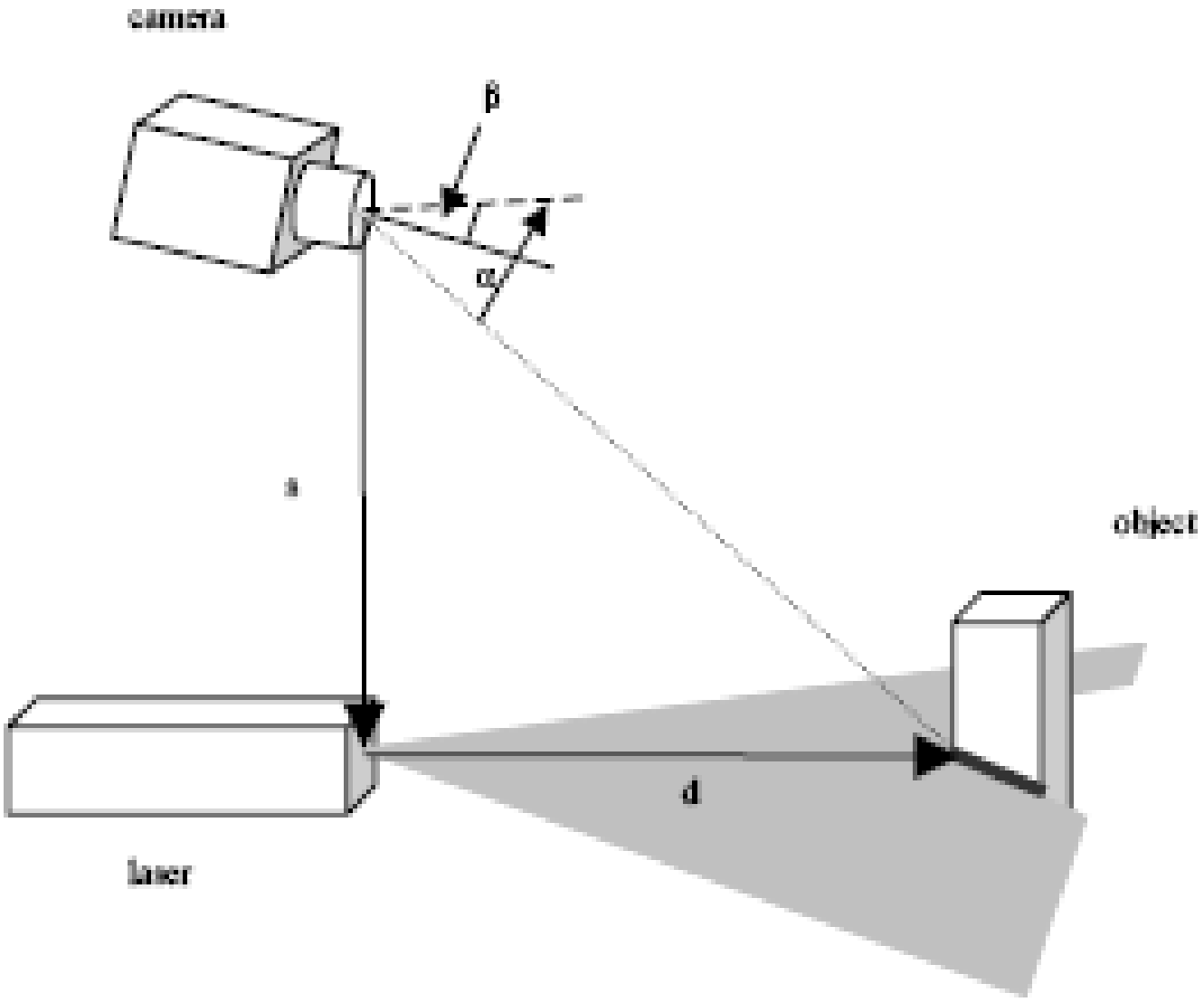
Signal Format	NTSC (PAL)
Image Sensor	1/3 inch, Interline CCD x 2
Effective Picture Element	768H x 494Vmm
Total Effective Pixel	811 x 508Vmm
Scanning System	2: 1 Interlace
Sync, System	Internal Sync
H,V Sysnc	H:15. 734Hz V:59.94Hz, (H:15.625Hz)
Video Output	VBS, Y/C
Output Format	L Camera Output, R Camera Output, Field
Camera Control	Shutter, White Balance, Gain
Manual Zoom Lens Mono Focal Lens	F8-48mm KS55ZS F4.8 KS55MS
Lens Mount	C Mount
Lens Control	Zoom, Focus, Iris
Effective Operate Time	120 min (at 25 degrees)
Power Consumption	7W at 12V
Operating Temperature	10 degrees C – 40 degrees C
Weight	1.6kg
Size	W: 130 x H: 60 x D: 235 (mm) w/o lens

exercise

- It seems really trivial: point two cameras at the same scene, make a few distance and angle measurements to establish their location and orientation relative to each other, identify corresponding points in the two perspective views of the same scene, and – by high school trigonometry – compute the distance to each of those points. So why have so many billions of dollars been spent over the last 50 years on this as-yet in-general unsolved problem?

spatial-domain structured light

- the corresponding point problem is hard!
- make your life easier by structuring the illumination so corresponding points are easily identified
- for example ...
  - scan a laser spot over the scene
    - easy to find it even in a complicated scene
  - illuminate with a checkerboard pattern and find the square corners in each view
    - easy to find them even in a complicated scene


camera
β
α
s
object
d
laser

temporal domain structured light

- use temporally-modulated illumination
- use high-speed shutter to accept only light with a particular ToF, i.e., light coming from only a particular range window
- scan through range of times-of-flight to build up a complete range image
- render the image by labeling range with gray level, color, etc

depth from modulated illumination

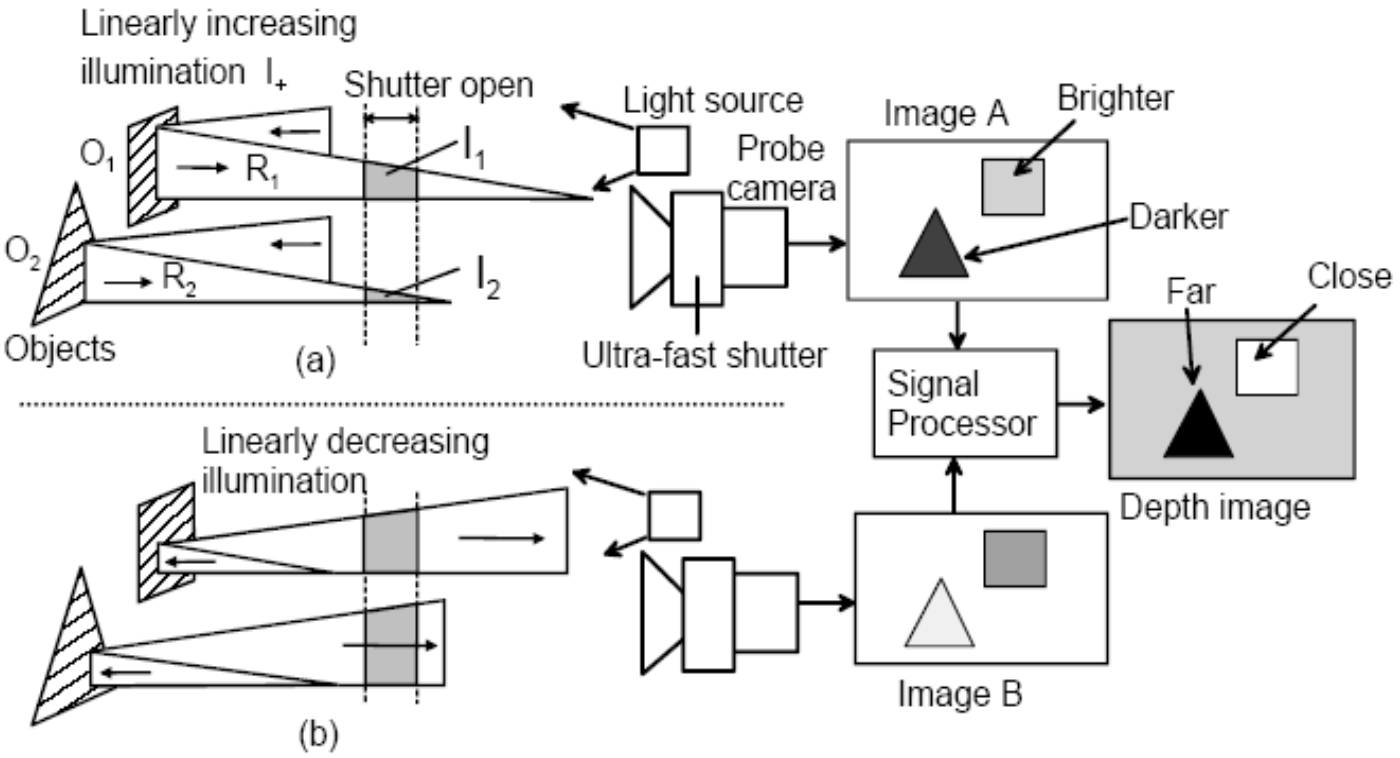


Figure 1 - Principle of acquiring a depth image by combining modulated illumination and an ultra-fast shutter. (a) Linearly increasing illumination. (b) Linearly decreasing illumination.

CSEM

- LEDs emit modulated light
- range range 7.5 to 20 m depending on modulation frequency
  - the usual tradeoff between sensitivity and resolution
- claims 5 mm depth accuracy using camera with160 x 124 pixel CMOS BCCD sensor
- see http://www.csem.ch/detailed/p_531_3d_cam.htm

depth map from CSEM camera