industrial 3D robotics

A Comparison of 3D Technologies

STEREO

Time-of-flight Cameras

LIDAR

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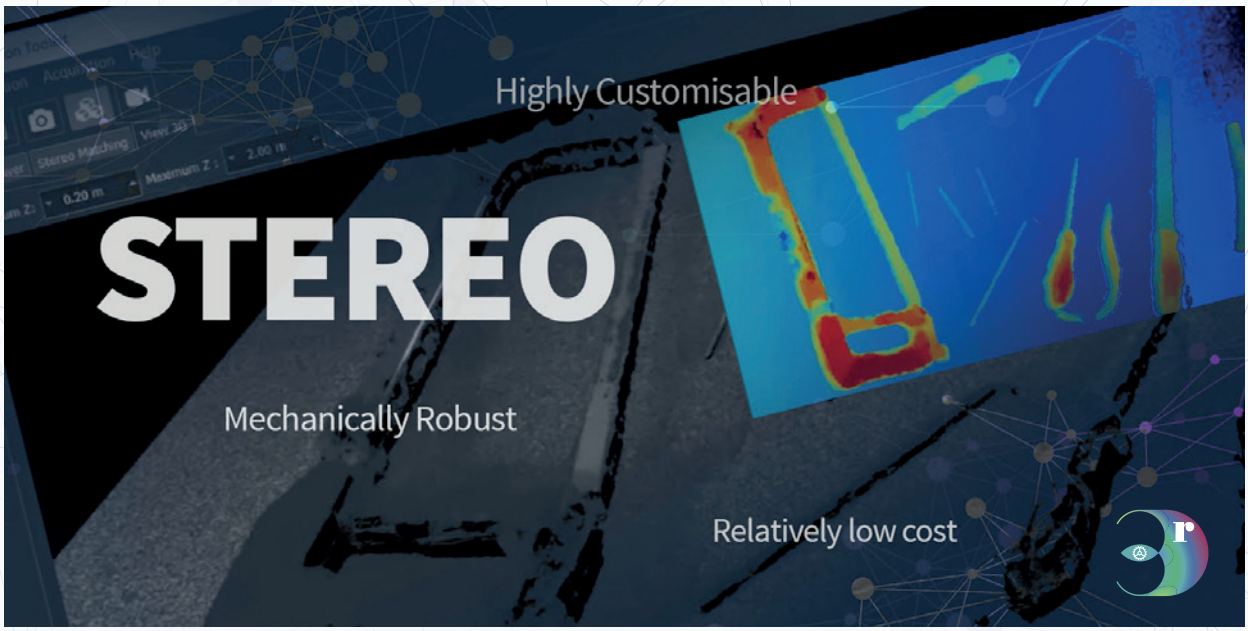


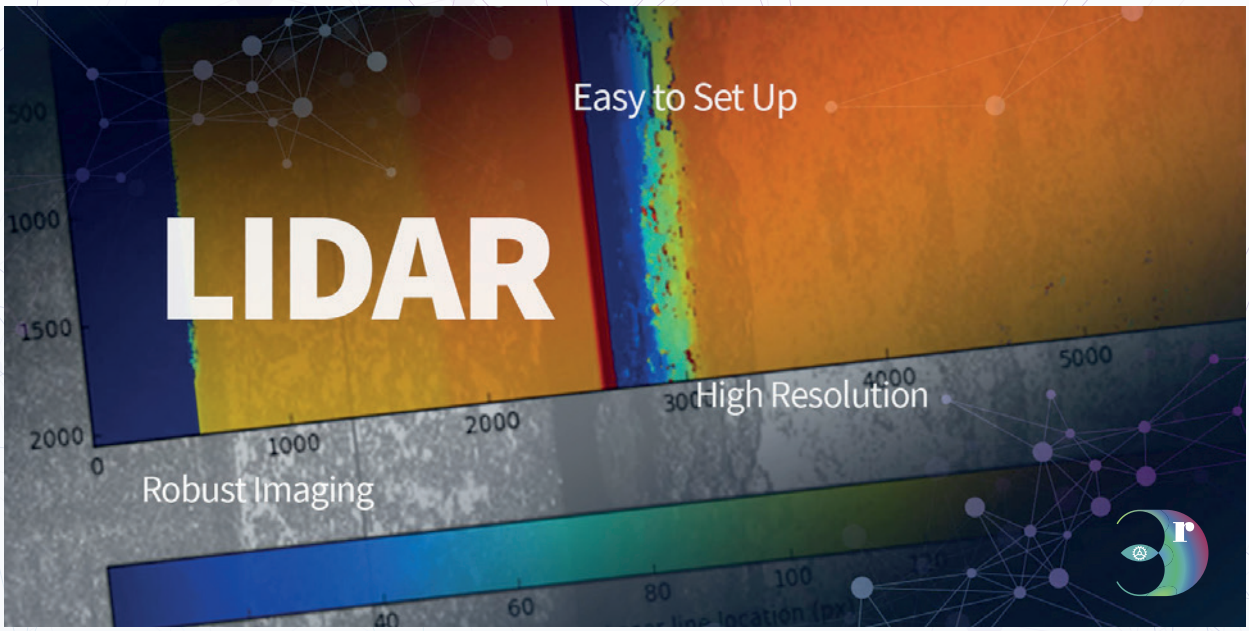
STEREO

Advantages

- Relatively low cost – ranging from a few £100s. Even industrial units cost less than an entry-level LIDAR scanner
- Highly customisable (lens choices, filters, baselines, ruggedisation, etc)
- Obtain both 2D and 3D data. 2D information may be more beneficial for image analysis (e.g. defect detection) and machine learning.
- Can overlay image intensity/colour directly on 3D
- Output is a point cloud
- Highest resolution of any 3D imaging solution (megapixels)
- High data rates (stereo may be produced at 60fps for low-resolution images). Images may be acquired in a few ms.
- Suitable for imaging moving targets
- Power consumption is low (can be powered from USB alone)
- Mechanically robust – no moving parts
- Accuracy is very good (sub-mm for Phobos)
- Works indoors and outdoors
- May use different algorithms depending on scene/task
- Calibration is straightforward and may be done by the end-user
- Stereo camera systems which make 1 million + measurements per observation are inherently resistant to high temperature and humidity levels therefore can provide information regardless of ambient air temperatures. This makes stereo more practical and more deployable.

Disadvantages

- Reconstruction relies on there being lots of features in the scene
- Accuracy is quadratically dependent on the range (e.g. double distance, accuracy down by a factor of four)
- Passive sensing so may need illumination (especially if dark/ featureless surface)
- High-resolution algorithms will need high-performance GPUs.
- Potentially needs expert oversight to advise on the best setup for a particular scene (lots of parameters)



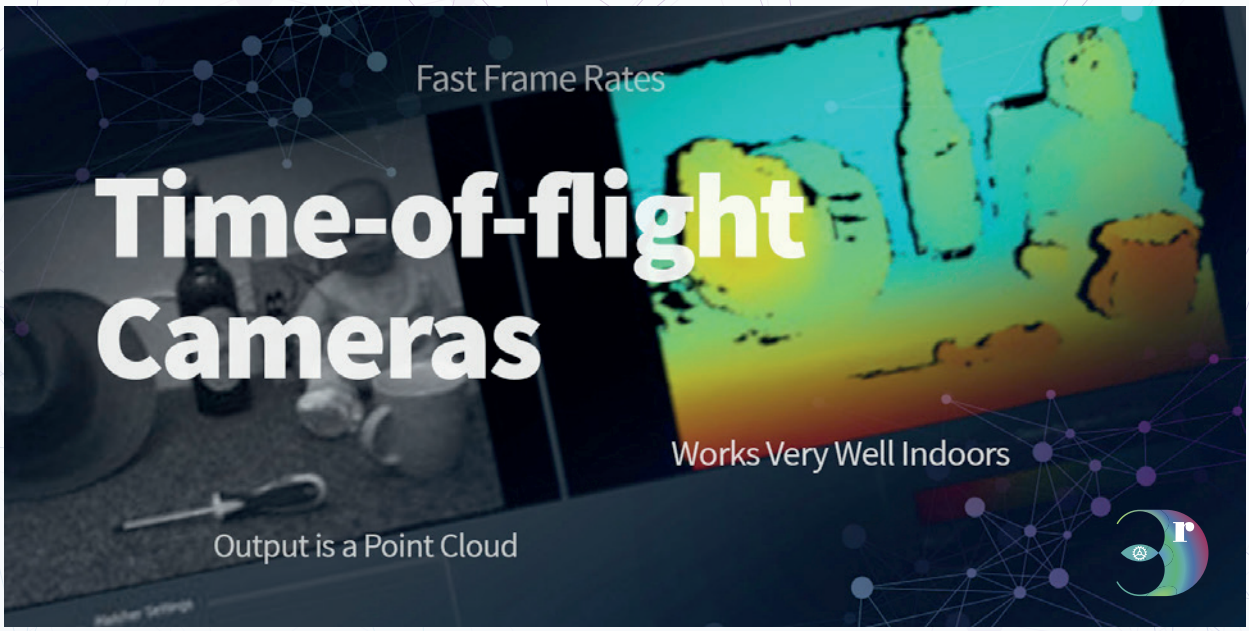
LIDAR

Advantages

- Easy to set up
- Very robust imaging – can reconstruct virtually any opaque surface
- Output is a point cloud
- Good accuracy over full measurement range (mm to cm)
- Can measure up to hundreds of metres
- High resolution – scans can be arbitrarily dense at the expense of scanning time; pretty fast – 1M point per second typical now
- Works indoors and outdoors
- Calibration usually not required by the user

Disadvantages

- Intensity information (colour) must be overlaid using a separate, calibrated, camera
- System must be scanned
- Somewhat mechanically robust, but contains precision moving parts (not good for many industrial environments
- Not suitable for extended use in harsh environments (though many systems are weatherproof/IP rated for outdoor use)
- Not suitable for moving targets
- Scans tend to be sparse, or can spend more time to 'fill in the gaps'
- Expensive, systems start at £20k
- Needs a lot of power
- Heavy and bulky (although newer automotive LIDAR will change this)
- Is susceptible to 'heat haze' when the air temperature exceeds 23 C, particularly, if there is a high level of humidity when the air can become turbulent. In extreme cases, the heat can make laser light scintillate destroying any information.



Time-of-flight Cameras

e.g. Kinect v2 ("Kinect for Xbox One"), SwissRanger

Advantages

- Can be very low cost (< £100) but comparable to stereo systems for industrial units
- Reasonably high resolution (1MP)
- Fast frame rates (30 fps)
- Images an area, just like a camera
- Works very well indoors – fine on featureless objects
- Output is a point cloud

Disadvantages

- Calibration performed by the manufacturer
- Illumination is power hungry so units require wall power
- Quite heavy, mostly due to cooling/heatsinks
- Doesn't work outside because of NIR illumination
- Only usable to around 10 m
- Requires NIR reflective surfaces
- Can get inaccurate ranges depending on object colour, system temperature, etc. calibration of this is not trivial