Seminar of Parallel Programming

Parallel algorithms for stereo vision

Xenophon Ruan

4 “What” 1 “How” & 1 “Why”

- What is StereoVision
- What's the difference between sterevision and normal vision.
- What is to be done (Stereovision)
- Why we need it (Parallel)
- How it works
- What is the result

What is “stereovision”

Stereovision is the process in visual perception leading to the sensation of depth from the two slightly different projections of the world onto the retinas of the two eyes.

Two images from camera

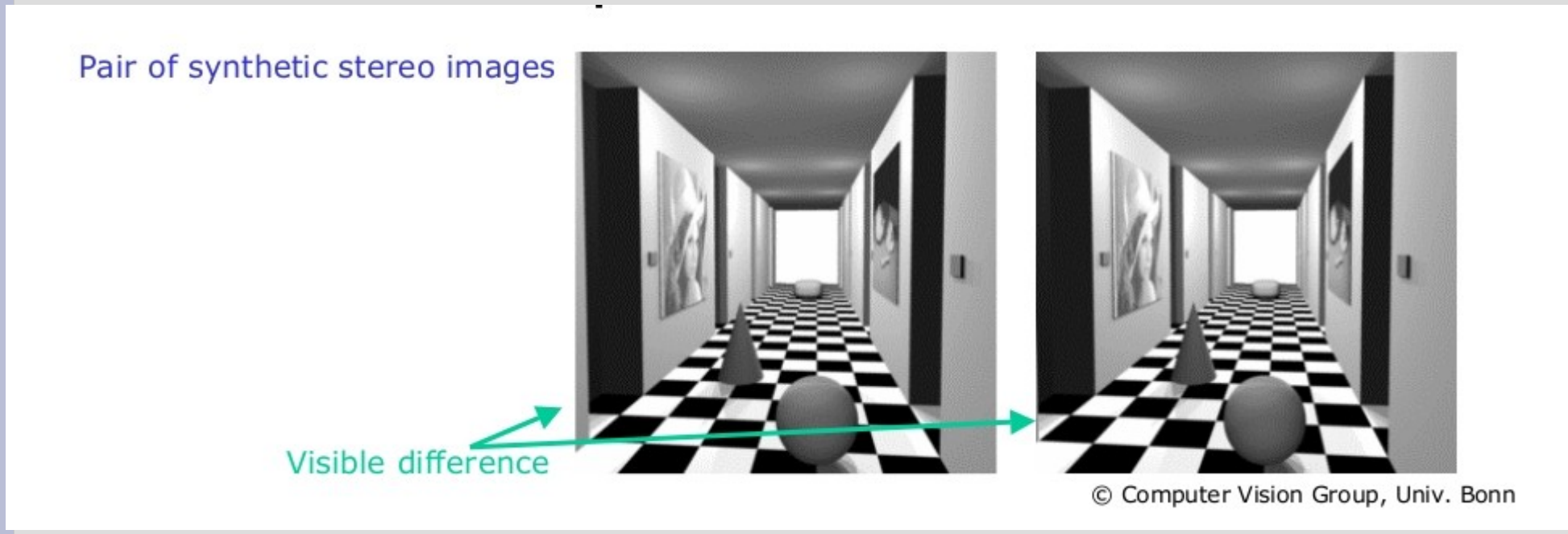
- Left

- Right

Mix them directly

Two images from camera

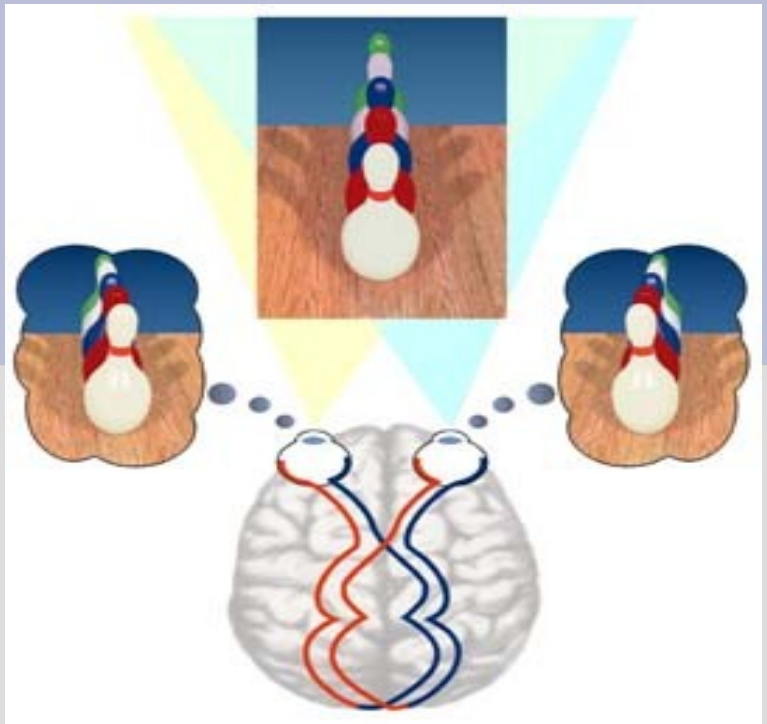
- Left
- Right



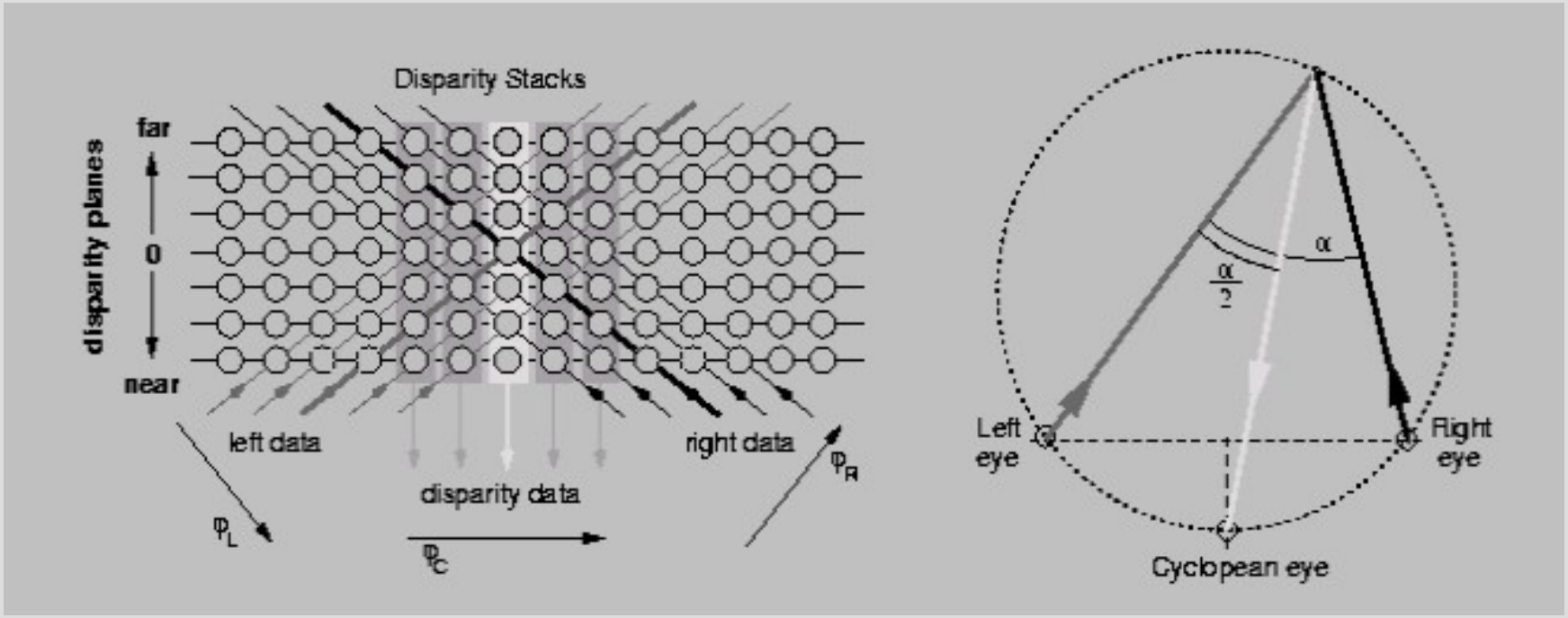
Stereo Vision - What is to be done?

1. Selection of proper distance between cameras and of proper focal lengths of the lens system
   The stereo vision experiment has to be set-up such, that the objects to be reconstructed are imaged by both cameras and the depth resolution satisfies the requirements of the application
2. Geometric Camera Calibration
   It is essential the exact geometry of the cameras relative to the world is known and that any non-linear distortions of the projection may be inverted.
3. Finding conjugate pairs
   Constraints need to be posed for resolving ambiguities that arise when corresponding locations are to be found.
4. Depth (location) computation
   Computation by triangulation

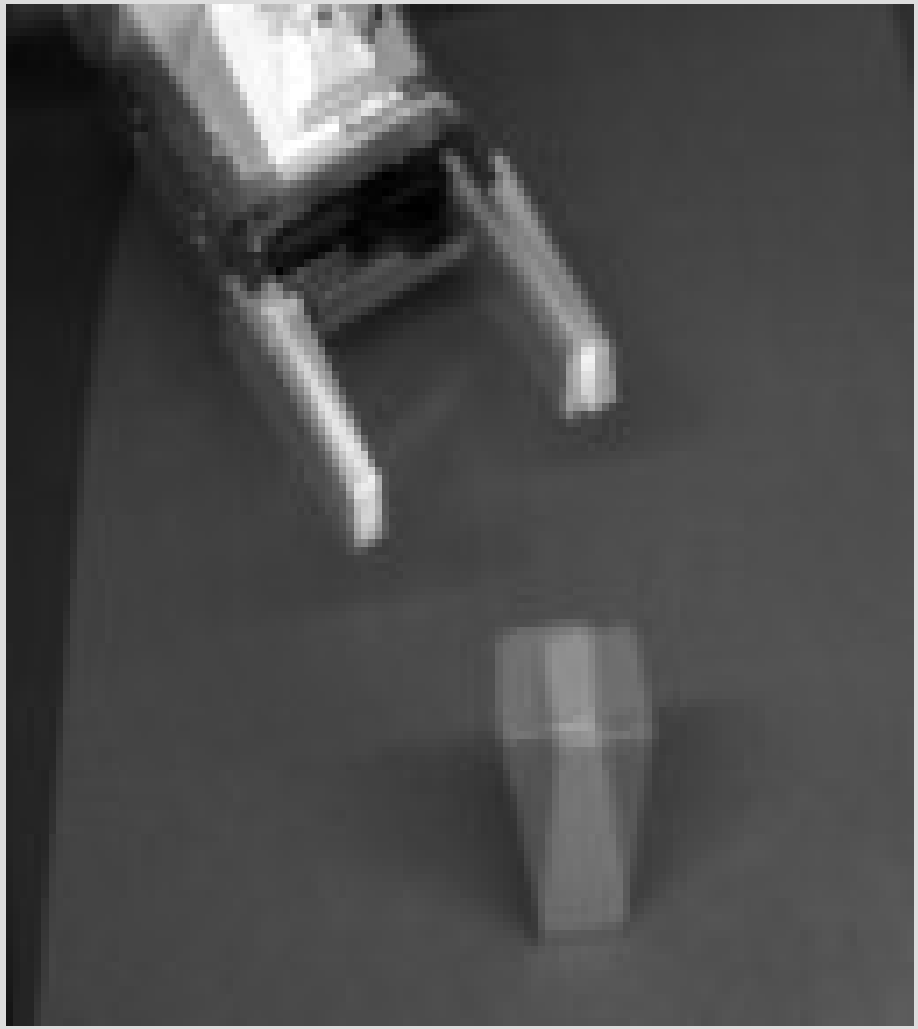
(5. Surface Computation)
   3-d information at locations, where the correspondence problem is solved, may be input for computing continuous surfaces of the visible part of the object and may help to infer the complete surface.



- Cyclopean View

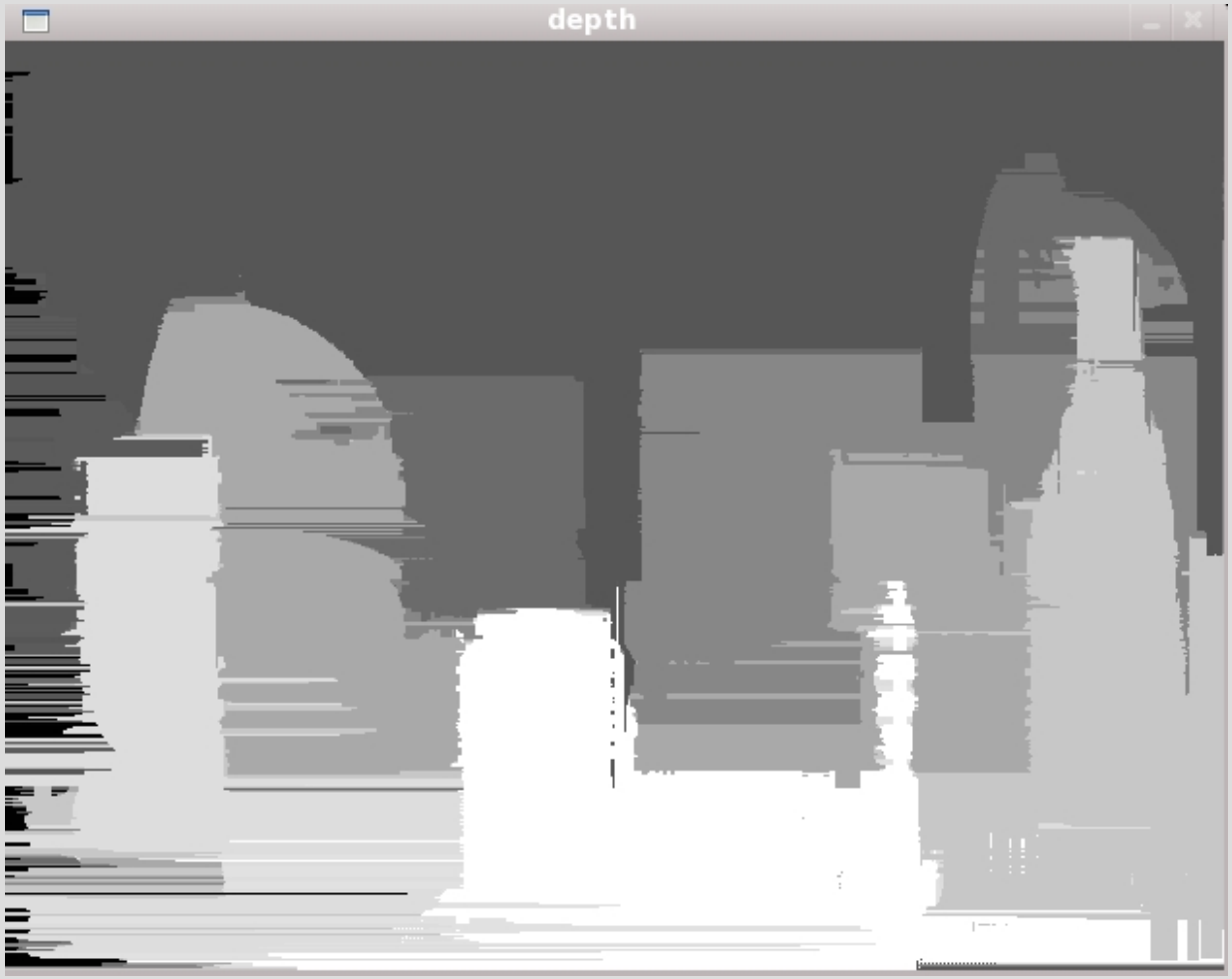


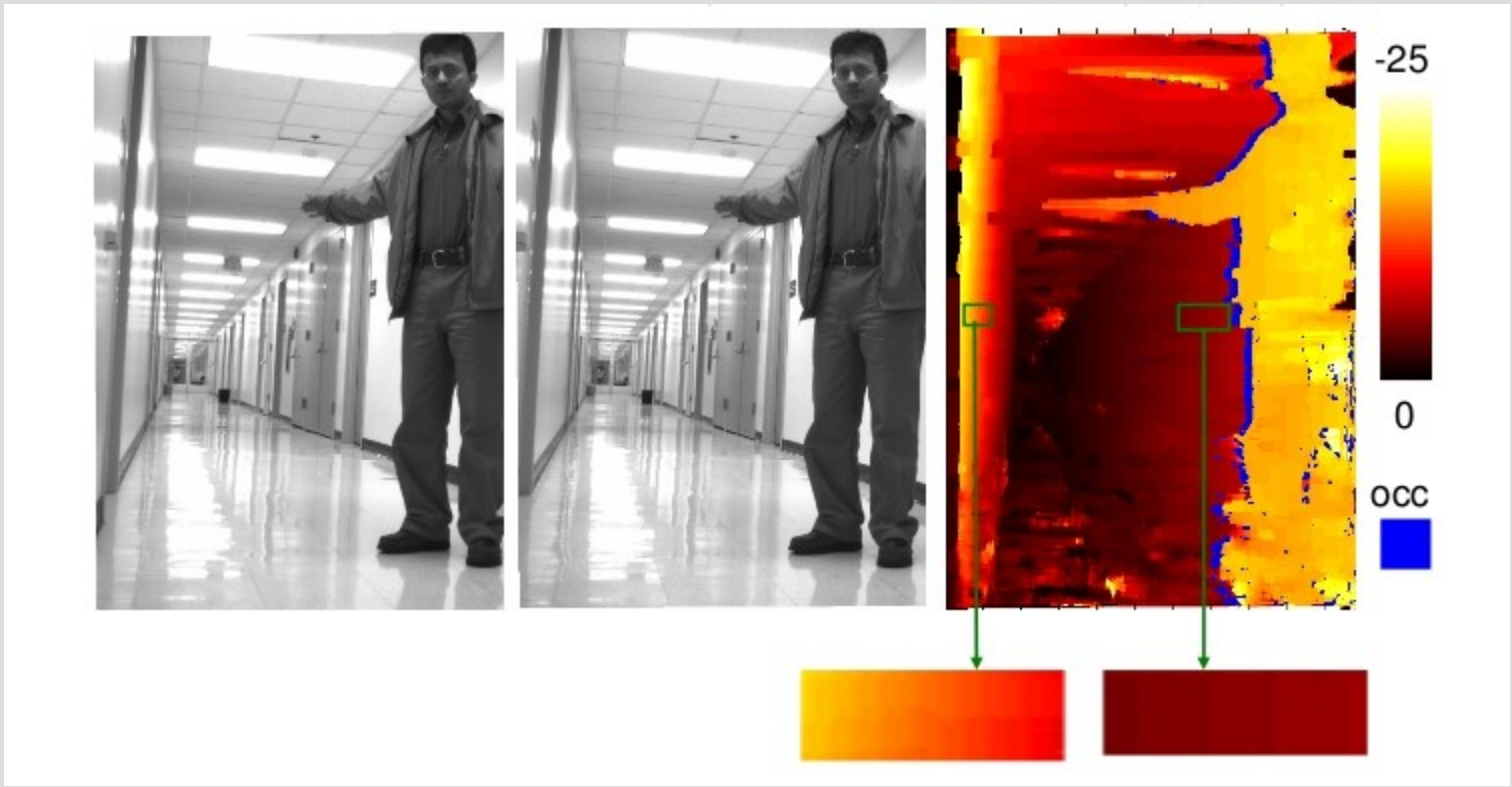
Cyclopean View & Overlay



Two images from two “eyes”

Depth (OpenCV cvFindStereoCorrespondence)

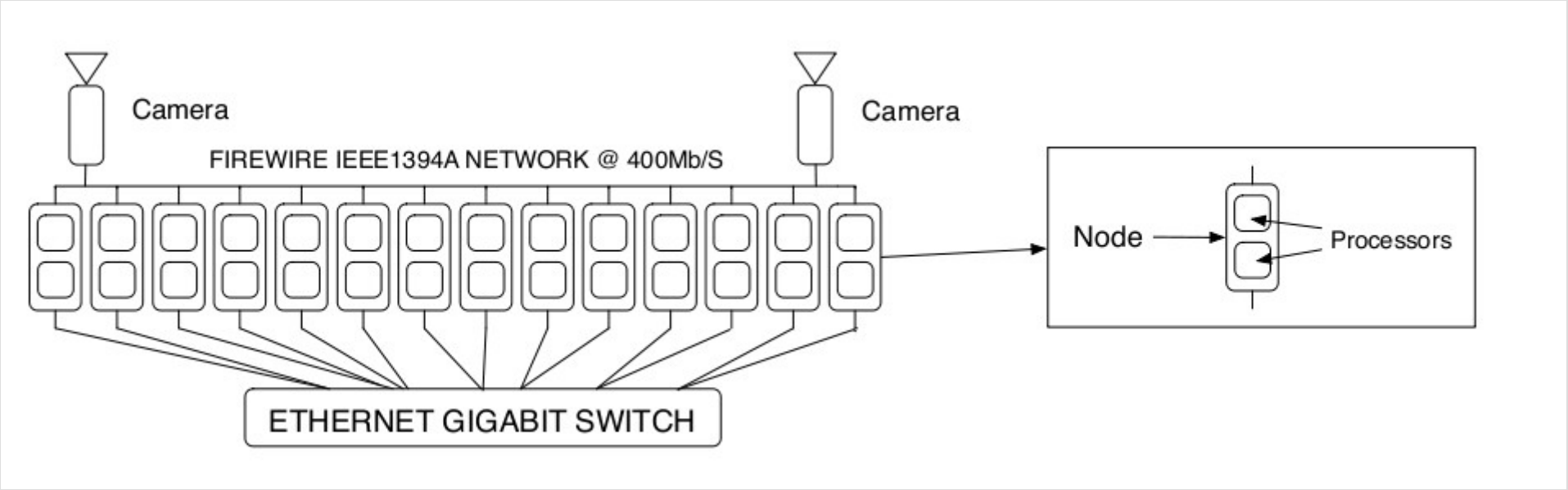



-25
0
occ

What we can do

- Real-time stereovision
- Parallel

Cluster architecture



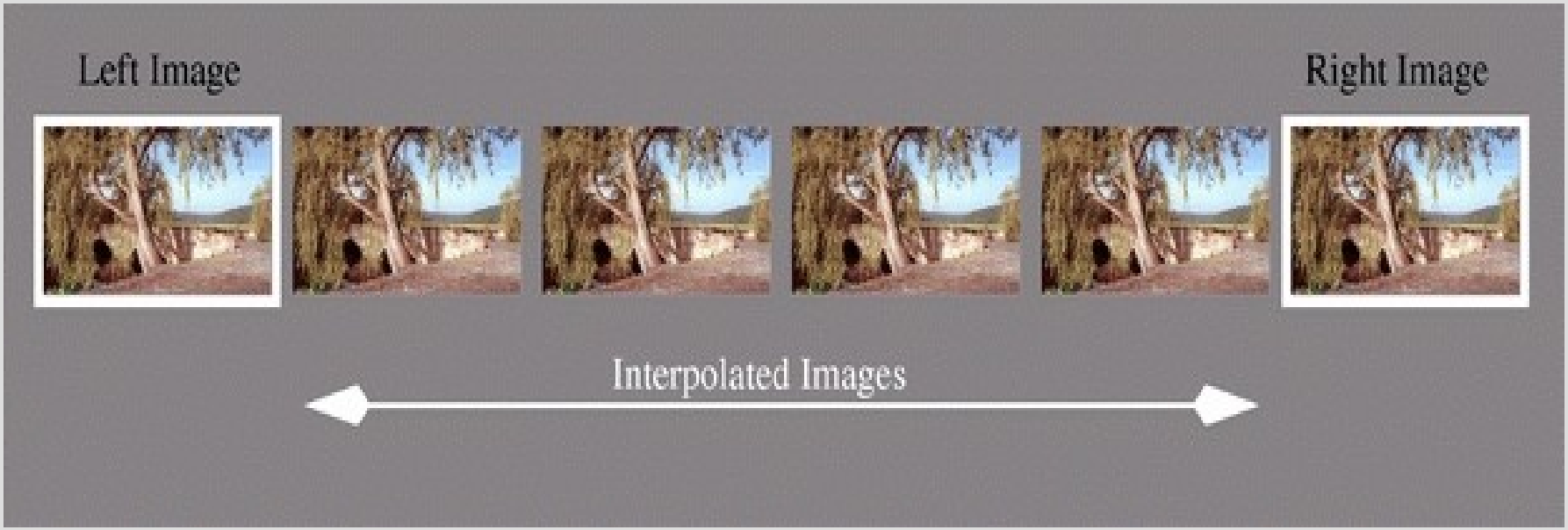
```
struct Data : public MPIData<Data>
{
  Frame input;
  Frame output;
};

struct Work : public Task<Work>
{
  bool operator()( Data& d )
  {
    d.output = where(d.input > 127, 255, 0);
    return true;
  }
};

int main(int argc, const char** argv )
{
  Data    d;
  Camera  camera( 30, res640x480, 8 );
  Cluster cluster(argc,argv);

  task_list(RowSplit<Frame>,Work,RowMerge<Frame>) act;
  cluster.task() = (SCM<act>(cluster.root(),cluster.world()));

  camera >> d.input;
  cluster.run(d);

  return 0;
}
```

A cluster synchronization step

By using a message passing based synchronization (using MPI_Barrier) to force all nodes to wait each other before acquiring the next frame we force the synchronization of frame acquisition on all nodes.
This synchronization has to be explicitely triggered by the user.

Result

Step	Seq	np=2	np=4	np=8	np=16	np=24	np = 28
RECTIF	$246ms$	$139.1ms$	$70.5ms$	$36.1ms$	$19.5ms$	$13.1ms$	$12.6ms$
DETECT	$262ms$	$80.1ms$	$40.5ms$	$20.6ms$	$11.2ms$	$7.1ms$	$6.4ms$
MATCH	$304.2ms$	$180ms$	$91.5ms$	$47.4ms$	$22.4ms$	$13.8ms$	$9.7ms$
BUILD	$180ms$	$100ms$	$53ms$	$27.5ms$	$18.2ms$	$12.0ms$	$9.5ms$
TOTAL	$992.2ms$	$479.2ms$	$244.6ms$	$122.6ms$	$68.2ms$	$42.9ms$	$38.2ms$
FPS	1.02	2.08	4.08	8.15	14.66	23.31	26.17


Left Image
Right Image
Interpolated Images

Example of the Cyclopean View

Ref.

Rolf Hekel's Stereovision

http://axon.physik.uni-bremen.de/index.htm

3D Vision

http://e-spacy.com/blog/3d-stereo-visual-t

Vision3D

http://www.vision3d.com/stereo.html

Stereopsis,Wikipedia

http://en.wikipedia.org/wiki/Stereopsis

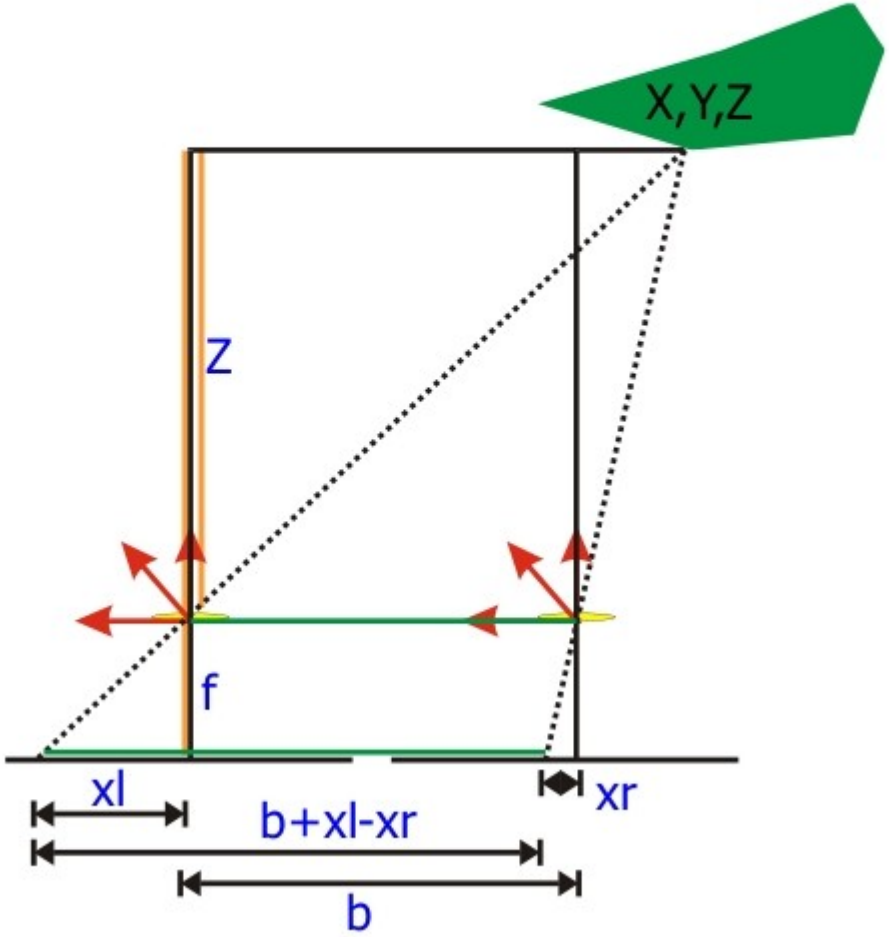
3D Computer Vision, 5. Stereo Vision (Introduction), Klaus D. Toennies

Ref.

Shape and the stereo correspondence problem,Abhijit S. Ogale and Yiannis Aloimonos

Real-Time Correlation-Based Stereo Vision with Reduced Border Errors,Heiko Hirschm¨ller, Peter R. Innocent and Jon Garibaldiu

Computing Z from the disparity



Application of the intercept theorem (with x_l-x_r equalling disparity d):

$$\frac{Z}{Z+f} = \frac{b}{b+x_l-x_r}$$

$$\Leftrightarrow Z\left(b+x_l-x_r\right) = b\left(Z+f\right)$$

$$\Leftrightarrow Z\left(x_l-x_r\right) = bf$$

$$\Leftrightarrow Z = \frac{bf}{x_l-x_r} = \frac{bf}{d}$$

Thank you for listening.