STEREO VIDEO CAMERAS

POINT GREY HAS MADE STEREO VISION PRACTICAL

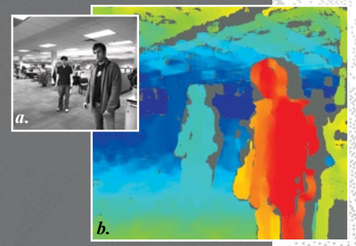
for a variety of research areas by providing hardware and software packages that include complete stereo processing support – from image correction and alignment to dense correlation-based stereo mapping. Stereo vision works in a similar way to 3D sensing in human vision. It begins with identifying image pixels that correspond to the same point in a physical scene observed by multiple cameras. The 3D position of a point can then be established by triangulation using a ray from each camera. The more corresponding pixels identified, the more 3D points that can be determined with a single set of images. Correlation stereo methods attempt to obtain correspondences for every pixel in the stereo image, resulting in tens of thousands of 3D values generated with every stereo image.

TRICLOPS™ STEREO SDK

The Triclops SDK provides flexible access to all image stages in the stereo processing pipeline, making it ideal for custom stereo processing approaches. For example, users can track features in the distorted images, rectify feature locations only, use rectified locations to perform epipolar validation on the features, and then determine their locations in 3D. Or users can rectify images and implement a user-supplied stereo algorithm, or perform correlation stereo only in regions of interest in the image, to speed up stereo processing. This flexibility enables innovation in a wide range of stereo vision research and application.

TRICLOPS SDK FEATURES INCLUDE:

- Distance Measurement for every pixel in view
- Over 1,000,000 measurements per second
- Removes lens distortions and misalignments
- Extensive example programs and source code



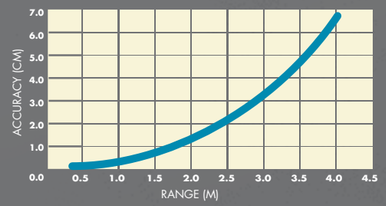
a. Original Image *b.* Depth Image

IMAGE RECTIFICATION

Raw Image Rectified Image

RANGE VS ACCURACY

This chart shows the accuracy of 3D point calculations versus the range to the point. Results are dependent on image resolution, lens focal length and calibration accuracy.



This chart was generated for a 3.8 mm Bumblebee2 camera with a stereo resolution of 512x384 and typical calibration accuracy.

a. Original Image *b.* Depth Image

BUMBLEBEE CAMERA FAMILY KEY FEATURES

- Full field-of-view depth measurements from a single image set
- Real time transformation of images to 3D data. Cameras can easily generate one million 3D points per second
- Easy integration with other machine vision techniques. The images and 3D data are perfectly registered
- Passive 3D sensing – no lasers or projectors required
- Pre-calibration for lens distortion and camera misalignments. Epipolar lines are aligned to within 0.05* pixels RMS error
- No manual adjustments or in-field calibration required
- High quality Sony CCD sensors
- Flexible software environment that provides access to all levels of the stereo processing pipeline

* This figure is based on a stereo resolution of 320x240 and is valid for all camera models. Calibration accuracy will vary from camera to camera.

BUMBLEBEE® XB3

3-SENSOR AND MULTI-BASELINE

Model#	Sensor Specifications			Shutter		Max Res	Max FPS	Focal Length
BBX3-13S2C/M-38	1.3MP	Sony ICX445 CCD	1/3"	3.75 µm	Global	1280 x 960	16 fps	3.8 mm
BBX3-13S2C/M-60	1.3MP	Sony ICX445 CCD	1/3"	3.75 µm	Global	1280 x 960	16 fps	6 mm

BUMBLEBEE® 2

COMPACT SIZE AND QUALITY

Model#	Sensor Specifications			Shutter		Max Res	Max FPS	Focal Length
BB2-03S2C/M-25	0.3MP	Sony ICX424 CCD	1/3"	7.4 µm	Global	648 x 488	48 fps	2.5 mm
BB2-03S2C/M-38	0.3MP	Sony ICX424 CCD	1/3"	7.4 µm	Global	648 x 488	48 fps	3.8 mm
BB2-03S2C/M-60	0.3MP	Sony ICX424 CCD	1/3"	7.4 µm	Global	648 x 488	48 fps	6 mm
BB2-08S2C/M-25	0.8MP	Sony ICX204 CCD	1/3"	4.65 µm	Global	1032 x 776	20 fps	2.5 mm
BB2-08S2C/M-38	0.8MP	Sony ICX204 CCD	1/3"	4.65 µm	Global	1032 x 776	20 fps	3.8 mm
BB2-08S2C/M-60	0.8MP	Sony ICX204 CCD	1/3"	4.65 µm	Global	1032 x 776	20 fps	6 mm

BUMBLEBEE® XB3	BUMBLEBEE® 2	
Two IEEE-1394b interfaces for camera camera control, data, and power	IEEE-1394a interfaces for camera camera control, data, and power	INTERFACE
4 general-purpose digital input/output pins	4 general-purpose digital input/output pins	GPIO
12-bit	12-bit	A/D
YUV411, YUV422, and RGB formats	YUV411, YUV422, and RGB formats	IMAGE DATA FORMATS
8, 12, 16 and 24-bit digital data	8, 12, 16 and 24-bit digital data	VIDEO DATA OUTPUT
Automatic/Manual/One-Push Gain modes, 0 dB to 24 dB	Automatic/Manual/One-Push Gain modes, 0 dB to 24 dB	GAIN
12 cm and 24 cm	12 cm	BASELINE
3.8 mm with 66° HFOV, 6 mm with 43° HFOV	2.5 mm with 97° HFOV, 3.8 mm with 66° HFOV, 6 mm with 43° HFOV	FIELD OF VIEW
f/2.0 (2.5 mm and 3.8 mm focal length), f/2.5 (6.0 mm focal length)	f/2.0 (2.5 mm and 3.8 mm focal length), f/2.5 (6.0 mm focal length)	APERTURE
54 dB	60 dB	SIGNAL TO NOISE RATIO
Standard, bulb, skip frames, overlapped	Standard, bulb, skip frames, overlapped	TRIGGER MODES
Automatic/Manual 0.03 ms to 66.63 ms at 15 FPS	Automatic/Manual 0.03 ms to 66.63 ms at 15 FPS	SHUTTER
277 x 37 x 41.8 mm	157 x 36 x 47.4 mm	SIZE (WXHXD)
505 g	342 g	MASS
4 W at 12 V via IEEE-1394 interface or GPIO connector	2.5 W at 12 V via IEEE-1394 interface or GPIO connector	POWER
3 x M12 microlens mount	2 x M12 microlens mount	LENS MOUNT
-30° to 60°C (storage) • 0° to 45°C (operating)	-30° to 60°C (storage) • 0° to 45°C (operating)	TEMPERATURE
2 years	2 years	WARRANTY

FireWire

FireWire

	MODEL NUMBER	INTERFACE	SENSOR TYPE	OPTICAL FORMAT	PIXEL SIZE	MAX RES	MAX FPS	SHUTTER	LENS MOUNT	A/D CONVERTER	VIDEO DATA OUTPUT	ON-BOARD MEMORY	SIZE	OPERATING TEMP	WARRANTY
FLEA3 Page 2	FL3-U3-13S2M-CS	USB 3.0	Sony IMX035 CMOS	1/3″	3.63µm	1328x1048	120 fps	Rolling	CS	12-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	29 x 29 x 30 mm	0° to 45° C	3 years
	FL3-U3-13Y3M-C	USB 3.0	ON Semi VITA1300 CMOS	1/2″	4.8µm	1280x1024	150 fps	Global	C	10-bit ADC		1 MB flash memory			
	FL3-U3-13E4C/M-C	USB 3.0	e2v EV76C560 CMOS	1/1.8″	5.3µm	1280x1024	60 fps	Global	C	10-bit ADC					
	FL3-U3-32S2C/M-CS	USB 3.0	Sony IMX036 CMOS	1/2.8″	2.5µm	2080x1552	60 fps	Rolling/Global Reset	CS	12-bit ADC					
	FL3-U3-88S2C-C	USB 3.0	Sony IMX121 CMOS	1/2.5″	1.55µm	4096x2160	21 fps	Rolling/Global Reset	C	12-bit ADC					
GRASSHOPPER3 Page 2	GS3-U3-23S6C/M-C	USB 3.0	Sony IMX174 CMOS	1/1.2″	5.86µm	1920x1200	165 fps	Global	C	10-bit ADC	8, 12, 16, 24-bit	128 MB frame buffer	44 x 29 x 58 mm	0° to 45° C	3 years
	GS3-U3-28S4C/M-C	USB 3.0	Sony ICX687 CCD	1/1.8″	3.69µm	1928x1448	26 fps	Global	C	14-bit ADC		512 KB flash memory			
	GS3-U3-28S5C/M-C	USB 3.0	Sony ICX674 CCD	2/3″	4.54µm	1920x1440	26 fps	Global	C	14-bit ADC					
	GS3-U3-41C6C/M-C	USB 3.0	CMOSIS CMV4000 CMOS	1″	5.5µm	2048x2048	90 fps	Global	C	10-bit ADC					
	GS3-U3-50S5C/M-C	USB 3.0	Sony ICX625 CCD	2/3″	3.45µm	2448x2048	15 fps	Global	C	14-bit ADC					
	GS3-U3-60S6C/M-C	USB 3.0	Sony ICX694 CCD	1″	4.54µm	2736x2192	13 fps	Global	C	14-bit ADC					
	GS3-U3-91S6C/M-C	USB 3.0	Sony ICX814 CCD	1″	3.69µm	3376x2704	6 fps	Global	C	14-bit ADC					
BLACKFLY Page 3	BFLY-PGE-05S2C/M-CS	GigE	Sony ICX693 CCD	1/3″	6.0µm	808x608	50 fps	Global	CS	12-bit ADC	8, 12, 16, 24-bit	16 MB frame buffer	29 x 29 x 30 mm	0° to 45° C	3 years
	BFLY-PGE-09S2C/M-CS	GigE	Sony ICX692 CCD	1/3″	4.08µm	1288x728	30 fps	Global	CS	12-bit ADC		512 KB flash memory			
	BFLY-PGE-12A2C/M-CS	GigE	Aptina AR0134 CMOS	1/3″	3.75µm	1280x960	52 fps	Global	CS	12-bit ADC					
	BFLY-PGE-13S2C/M-CS	GigE	Sony ICX445 CCD	1/3″	3.75µm	1288x964	22 fps	Global	CS	12-bit ADC					
	BFLY-PGE-13E4C/M-CS	GigE	e2v EV76C560 CMOS	1/1.8″	5.3µm	1280x1024	60 fps	Global	CS	10-bit ADC					
	BFLY-PGE-14S2C-CS	GigE	Sony IMX104 CMOS	1/3″	3.75µm	1296x1032	60 fps	Rolling	CS	12-bit ADC					
	BFLY-PGE-20E4C/M-CS	GigE	e2v EV76C570 CMOS	1/1.8″	4.5µm	1600x1200	47 fps	Global	CS	10-bit ADC					
	BFLY-PGE-23S2C-CS	GigE	Sony IMX136 CMOS	1/2.8″	2.8µm	1920x1200	27 fps	Rolling	CS	12-bit ADC					
	BFLY-PGE-50A2C/M-CS	GigE	Aptina MT9P CMOS	1/2.5″	2.2µm	2592x1944	13 fps	Rolling	CS	12-bit ADC					
FLEA3 Page 3	FL3-GE-03S1C/M-C	GigE	Sony ICX618 CCD	1/4″	5.6µm	648x488	120 fps	Global	C	12-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	29 x 29 x 30 mm	0° to 45° C	3 years
	FL3-GE-03S2C/M-C	GigE	Sony ICX424 CCD	1/3″	7.4µm	648x488	82 fps	Global	C			1 MB flash memory			
	FL3-GE-08S2C/M-C	GigE	Sony ICX204 CCD	1/3″	4.65µm	1032x776	31 fps	Global	C						
	FL3-GE-13S2C/M-C/CS	GigE	Sony ICX445 CCD	1/3″	3.75µm	1288x964	31 fps	Global	C / CS						
	FL3-GE-14S3C/M-C	GigE	Sony ICX267 CCD	1/2″	4.65µm	1384x1032	18 fps	Global	C						
	FL3-GE-20S4C/M-C	GigE	Sony ICX274 CCD	1/1.8″	4.4µm	1624x1224	15 fps	Global	C						
	FL3-GE-28S4C/M-C	GigE	Sony ICX687 CCD	1/1.8″	3.69µm	1928x1448	15 fps	Global	C						
	FL3-GE-50S5C/M-C	GigE	Sony ICX655 CCD	2/3″	3.45µm	2448x2048	8 fps	Global	C						
GRASSHOPPER2 Page 4	GS2-GE-20S4C/M-C	GigE	Sony ICX274 CCD	1/1.8″	4.4µm	1624x1224	29 fps	Global	C	14-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	44 x 29 x 58 mm	0° to 45° C	3 years
	GS2-GE-50S5C/M-C	GigE	Sony ICX625 CCD	2/3″	3.45µm	2448x2048	15 fps	Global	C			512 KB flash memory			
ZEBRA2 Page 4	ZBR2-PGEHD-20S4C-CS	GigE/ HD-SDI	Sony ICX274 CCD	1/1.8″	4.4µm	1624x1224	30 fps (HD-SDI 25 FPS)	Global	CS	14-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	44 x 44 x 87.5 mm	0° to 45° C	3 years
	ZBR2-PGEHD-28S4C-CS	GigE/ HD-SDI	Sony ICX687 CCD	1/1.8″	3.69µm	1928x1448	26 fps (HD-SDI 25 FPS)	Global	CS			1 MB flash memory			
	ZBR2-PGEHD-50S5C-CS	GigE/ HD-SDI	Sony ICX625 CCD	2/3″	3.45µm	2448x2048	15 fps (HD-SDI 25 FPS)	Global	CS						
	ZBR2-PGEHD-50S5C-CS	GigE/ HD-SDI	Sony ICX655 CCD	2/3″	3.45µm	2448x2048	10 fps (HD-SDI 25 FPS)	Global	CS						
FLEA2 Page 6	FL2-03S2C/M-C	IEEE 1394b	Sony ICX424 CCD	1/3″	7.4µm	648x488	80 fps	Global	C	12-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	29 x 29 x 30 mm	0° to 45° C	3 years
	FL2-08S2C/M-C	IEEE 1394b	Sony ICX204 CCD	1/3″	4.65µm	1032x776	30 fps	Global	C			512 KB flash memory			
	FL2G-13S2C/M-C	IEEE 1394b	Sony ICX445 CCD	1/3″	3.75µm	1288x964	30 fps	Global	C						
	FL2-14S3C/M-C	IEEE 1394b	Sony ICX267 CCD	1/2″	4.65µm	1392x1032	15 fps	Global	C						
	FL2-20S4C/M-C	IEEE 1394b	Sony ICX274 CCD	1/1.8″	4.4µm	1624x1224	15 fps	Global	C						
	FL2G-50S5C/M-C	IEEE 1394b	Sony ICX655 CCD	2/3″	3.45µm	2448x2048	7.5 fps	Global	C						
FLEA3 Page 5	FL3-FW-03S1C/M-C	IEEE 1394b	Sony ICX618 CCD	1/4″	5.6µm	648x488	120 fps	Global	C	12-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	29 x 29 x 30 mm	0° to 45° C	3 years
	FL3-FW-03S3C/M-C	IEEE 1394b	Sony ICX414 CCD	1/2″	9.9µm	648x488	76 fps	Global	C			1 MB flash memory			
	FL3-FW-14S3C/M-C	IEEE 1394b	Sony ICX267 CCD	1/2″	4.65µm	1384x1032	16 fps	Global	C						
	FL3-FW-20S4C/M-C	IEEE 1394b	Sony ICX274 CCD	1/1.8″	4.4µm	1624x1224	15 fps	Global	C						
GRASSHOPPER EXPRESS Page 5	GX-FW-10K3M-C	IEEE 1394b	Kodak KAI-01050 CCD	1/2″	5.5µm	1024x1024	70 fps	Global	C	14-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	44 x 29 x 58 mm	0° to 45° C	3 years
	GX-FW-28S5C/M-C	IEEE 1394b	Sony ICX674 CCD	2/3″	4.54µm	1932x1452	26 fps	Global	C			1 MB flash memory			
	GX-FW-60S6C/M-C	IEEE 1394b	Sony ICX694 CCD	1″	4.54µm	2736x2192	11 fps	Global	C						
GRASSHOPPER Page 7	GRAS-03K2C/M-C	IEEE 1394b	Kodak KAI-0340D CCD	1/3″	7.4µm	648x480	200 fps	Global	C	14-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer	44 x 29 x 58 mm	0° to 40° C	3 years
	GRAS-03S3M-C	IEEE 1394b	Sony ICX414 CCD	1/2″	9.9µm	648x488	74 fps	Global	C			512 KB flash memory			
	GRAS-14S3C/M-C	IEEE 1394b	Sony ICX267 CCD	1/2″	4.65µm	1384x1032	21 fps	Global	C						
	GRAS-14S5C/M-C	IEEE 1394b	Sony ICX285 CCD	2/3″	6.45µm	1384x1036	15 fps	Global	C						
	GRAS-20S4C/M-C	IEEE 1394b	Sony ICX274 CCD	1/1.8″	4.4µm	1624x1224	30 fps	Global	C						
	GRAS-50S5C/M-C	IEEE 1394b	Sony ICX625 CCD	2/3″	3.45µm	2448x2048	15 fps	Global	C						
GRASSHOPPER2 Page 6	GS2-FW-14S5C/M-C	IEEE 1394b	Sony ICX285 CCD	2/3″	6.45µm	1384x1036	30 fps	Global	C	14-bit ADC	8, 12, 16, 24-bit	32 MB frame buffer 512 KB flash memory	44 x 29 x 58 mm	0° to 45° C	3 years
Page 7 **FIREFLY MV**	FFMV-03M2C/M-CS	IEEE 1394a	Micron MT9V022 CMOS	1/3″	6.0µm	752x480	60 fps	Global	CS	10-bit ADC	8, 16-bit	N/A	44 x 34 x 24.4mm	0° to 45° C	1 year
DRAGONFLY2 Page 8	DR2-COL/BW-CS	IEEE 1394a	Sony ICX424 CCD	1/3″	7.4µm	648x488	60 fps	Global	CS	12-bit ADC	8, 12, 16, 24-bit	512 KB flash memory	75 x 65 x 25.5 mm	0° to 45° C	1 year
	DR2-HICOL/BW-CS	IEEE 1394a	Sony ICX204 CCD	1/3″	4.65µm	1032x776	30 fps	Global	CS						
	DR2-13S2C/M-CS	IEEE 1394a	Sony ICX445 CCD	1/3″	3.75µm	1296x964	20 fps	Global	CS						
Page 9 **CHAMELEON**	CMLN-13S2C/M-CS	USB 2.0	Sony ICX445 CCD	1/3″	3.75µm	1296x964	18 fps	Global	CS	12-bit ADC	8, 16-bit	N/A	44 x 41 x 25.5 mm	0° to 45° C	1 year
FIREFLY MV Page 9	FMVU-03MTC/M-CS	USB 2.0	Micron MT9V022 CMOS	1/3″	6.0µm	752x480	60 fps	Global	CS	10-bit ADC	8, 16-bit	N/A	44 x 34 x 24.4 mm	0° to 45° C	1 year
	FMVU-13S2C-CS	USB 2.0	Sony IMX035 CMOS	1/3″	3.63µm	1328x1048	23 fps	Rolling	CS	12-bit ADC					
GAZELLE Page 8	GZL-CL-22C5-C	Camera Link Base/Full	CMOSIS CMV2000 CMOS	2/3″	5.5µm	2048x1088	280 fps	Global	C	10-bit ADC	8, 10-bit	4 MB flash memory	44 x 29 x 59.5 mm	-10° to 50° C	3 years
	GZL-CL-41C6-C	Camera Link Base/Full	CMOSIS CMV4000 CMOS	1″	5.5µm	2048x2048	150 fps	Global	C						
BUMBLEBEE2 & XB3 Page 14	BB2-03S2C/M (25/38/60)	IEEE 1394a	Sony ICX424 CCD	1/3″	7.4µm	648x488	48 fps	Global	2 x M12	12-bit ADC	8, 16-bit	N/A	157x 36 x 47.4 mm	0° to 45° C	2 years
	BB2-08S2C/M (25/38/60)	IEEE 1394b	Sony ICX204 CCD	1/3″	4.65µm	1032x776	20 fps	Global	2 x M12				157 x 36 x 47.4 mm		
	BBX3-13S2C/M (38/60)	IEEE 1394b	Sony ICX445 CCD	1/3″	3.75µm	1280x960	16 fps	Global	3 x M12				277 x 37 x 41.8 mm		
LADYBUG2	LD2-HICOL-KIT	IEEE 1394b	Sony ICX204 CCD	1/3″	4.65µm	1024x768 (x6)	30 fps	Global	N/A	12-bit ADC	8-bit	N/A	110 x 100 x 141 mm	0° to 45° C	1 year
LADYBUG3	LD3-20S4C-33	IEEE 1394b	Sony ICX274 CCD	1/1.8″	4.4µm	1600x1200 (x6)	15 fps	Global	N/A		8-bit		122 x 141 mm		1 year
Page 11 & 12 **LADYBUG5**	LD5-U3-51S5C-44	USB 3.0	Sony ICX655 CCD	2/3″	3.45µm	2048x2448 (x6)	10 fps	Global	N/A		8, 12, 16-bit		139.5 x 160 mm		2 years