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Comparison of Kinect and Bumblebee2 in Indoor Environments

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S.P.A.R.C.   REM 2011   1

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Introduction

Indoor mobile robot navigation requirements:
- Obstacle avoidance
- Traversable road extraction
- Face and body recognition
- Etc.

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Introduction (Cont'd)

To satisfy the requirements, different sensors which uses different techniques used:
- Stereo vision
- Laser range finding
- Light-pattern based ranging
- Etc.

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Introduction (Cont'd)

These sensors
- Developed for research purposes
- Have prices between 2500-85000$

Kinect
- High availability
- Low cost (150 $)

Technical Specs

Kinect[4] Bumblebee2[6]

Technical Specs (Cont'd)

	Technology	Speed (fps)	Resolution (pixels)	Ranging Limit (m)	Includes
Kinect[18]	Light - Pattern RGB-D	30	320x240	0.7-6.0	• IR Projector, • RGB Camera, • Monochrome CMOS Camera, • Microphone Array
Bumblebee2[6]	Stereoscopy	20	1024x768	-	• 2xCCD Camera

Experiments

Three set of experiments

- **Experiment 1:** Scene of objects from indoor environment with different light conditions.

- **Experiment 2:** Scene of a patterned object with different orientations.

- **Experiment 3:** Depth measurement of a known distance and measurement of an object's depth.
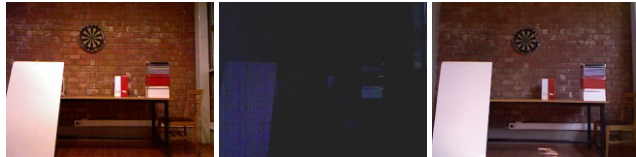
Experiment 1

Scene of objects from indoor environment with different light conditions.

- Night with artificial light
- Night without light
- Noon with indirect sunlight

Experiment 1 Results

Light Condition	% Avrage non-null Data		% Average Faulty Data		% Average Faulty Data on non-null Data	
	Pointgrey Bumblebee2	Microsoft Kinect	Pointgrey Bumblebee2	Microsoft Kinect	Pointgrey Bumblebee2	Microsoft Kinect
Night	21.41	97.89	1.26	0.00	6.37	0.00
Night with Light	75.87	97.79	1.24	0.00	1.67	0.00
Noon	79.66	93.61	0.82	0.00	1.04	0.00

- At night without enough light, Bumblebee2 cannot calculate the distance

- Kinect sensor gives the best result in dark and worst (still better than Bumblebee2) at noon.

- If Kinect can't calculate distance, it doesn't give faulty measurements, it just gives 0 (zero).

Experiment 2

Scene of a patterned object with different orientations.

- Pattern vertical
- Pattern 45 degrees
- Pattern horizontal
- Pattern 45 deg. Tilted around vertical
- Black cloth direct sunlight

Experiment 2 Results

Scenes	Average % Null Data		Ave % non-null Data	
	Pointgrey Bumblebee2	Microsoft Kinect	Pointgrey Bumblebee2	Microsoft Kinect
Pattern Vertical	20.2	0	79.8	100
Pattern 45 degrees	17.7	0	82.3	100
Pattern Horizontal	14.6	0	85.4	100
Pattern 45 deg Tilted Around Vertical	19.8	0	80.2	100
Black Cloth with Direct Sunlight	8.78	6.17	91.22	93.83

- A patterned texture can affect the readings of Bumblebee2 but doesn't affect Kinect's readings at all.

- Different orientations give similar results

- Direct sunlight affects both of the sensors. They can't retrieve data from the bright area.

Experiment 3

Depth measurement of a known distance and measurement of an object's depth.

- Depth of a box with known dimensions.
- Three measurements of known distance to a vertical plane.

Experiment 3 Results

Experiment	Ground Truth (cm)	Kinect Measurement (cm)	Bumblebee2 Measurement (cm)
Depth of Box	35.5	29.86	30.06
Distance 1	87.50	86.16	87.97
Distance 2	146.00	144.08	146.38
Distance 3	197.00	190.76	193.90

- Although Bumblebee2 measures more accurately, the accuracy of the both sensors is similar.

- The accuracy of Kinect decreases with increasing distance measurement more rapidly than Bumblebee2.

Conclusions

Kinect,

Advantages
- Superior for indoor usage considering its low price.
- Readings are independent of texture.
- Readings are independent of light condition.
- Has many fan clubs and a giant open source community

Disadvantages
- Can't measure outside in daylight.
- Indoor space with bright daylight has negative effects the measurements.

Bumblebee2,

Advantages
- Has no practical maximum distance limit in indoor.
- Has higher resolution.

Disadvantages
- Has a much higher cost.
- Patterned texture affects the measurements negatively.
- The scene must be well illuminated.

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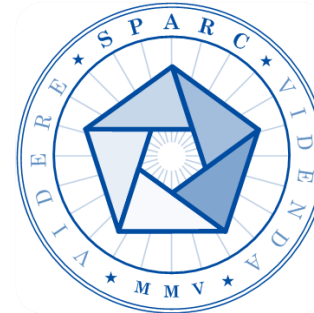
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Questions, Comments?