Electronic Perception Technology
Real-time single chip 3D imaging

Canesta has invented electronic perception technology, a low-cost sensor technology that enables everyday devices to perceive and interpret their surroundings in three dimensions and in real-time. This innovation is a CMOS-based, single chip imaging technology that generates frames of 3D information using a modulated infrared light source. Distance values are determined in each pixel of the sensor by measuring the difference in phase from the outgoing modulated light and the returning light. No additional processing is required.

This technology will soon be made available as a USB development system that may be used for developing and deploying electronic perception applications. This system, "Development Platform 200" (DP200), comes with a software development kit that provides access to raw frames of 3D information, enabling the rapid development of applications which utilize 3D information.

The system is suitable for the development of all kinds of applications, including for example:

- Size and depth detection – determining the size of an object or its distance from the device (e.g. enabling a robot to determine the size of a package and how far away it is; determining the size of a box, evaluating a cargo load)
- Image segmentation –separating the discrete objects in a scene (e.g., separating foreground from background or separating a human form from a picture on the wall)
- Object classification – identifying objects by class or type (e.g. determining whether a moving form is a human or animal)
- Object tracking & location analysis – determining the location, position and movement of an object (e.g., tracking the position of a car passenger's head to deploy an airbag properly, child monitoring systems, driver attention monitoring)
- Human interaction – watching human motion or body gestures to control electronic systems (e.g. automatic doors, gesture control for electronic systems)
- Many more possibilities…

DP200 Development Kit

When connected to a PC, the system operates "right out of the box" with no additional hardware development required. The system may also be implemented in a USB-based embedded system for deployment in applications where a PC is not available.

The DP200 includes a light source and corresponding optics which may be selected from a set of options. These options vary only by field of view and include 80 degree, 55 degree, and 30 degree options (Model # DP208, DP205, & DP203 respectively). Additional customized options may be developed for a separate fee.

In the future, the sensor chip at the heart of the DP200 will be available for integration into embedded systems.

Software Development Kit (SDK)

The software development kit provides an application programming interface (API) for writing applications for the DP200 using Microsoft Visual Studio 6.0 on a Windows 2000 or Windows XP PC. It supports the authoring, debugging, and execution of applications on a host PC in C or C++. The software development kit (SDK) provides access to raw brightness and depth image frames. The user can set sensor parameters, such as the frame rate, shutter speed, operation mode, window size, and the region of interest. The software

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development kit comes with documentation and sample code to illustrate the operation of the kit. It also includes a demo program that shows a color-coded 3D view of any object that is placed in the imaging area of the sensor.

The API is common across Windows and embedded platform implementations. Therefore, application software can be ported from the PC to a future embedded environment with a minimal amount of changes. The SDK provides programming guidelines for writing efficient embeddable applications.

Path to Embedded Deployments

Canesta's single chip solution offers two paths to embedded system deployment. The current DP200 module may be built into embedded system designs which include USB host or USB On-The-Go functionality. The entire DP200 module simply functions as a USB device.

Soon after DP200 becomes available, Canesta will offer the core perception chip for integration into embedded systems. The chip will provide depth and brightness values for each pixel in each frame over a standard embedded video interface such as a standard CMOS/CCD interface. The software SDK will also be available for porting. The performance characteristics of this embeddable chip will be the same as the chip used in the DP200 system. The precise electrical interface specifications of this chip are not yet published.

System Features:

- Real time 3-D and brightness video stream output at API level (up to 30 full frames/second).
- Real time raw information at module output level
- Built in IR Laser Array for active illumination
- Built-in IR filter for rejection of daylight interference
- Pre-calibrated units (usable out of the box) for one of the three optical field of view options.
- Dimensions 12.5cm x 6cm x 6.3cm with a standard tripod mount.
- A C-level SDK with API for
    - Start/stop of video stream
    - Access to depth, brightness separately
    - Adjusting frame rate
    - Setting shutter time
    - Setting digital gain
    - Setting minimum range
    - Setting maximum range
    - Setting light source power
    - Setting modulation frequency
    - Setting Window of Interest (WOI)
    - Setting ambient light rejection
- Toolkit Manager program and source code to visualize the depth and brightness images and change system operating properties
- Demo programs for
    - Object tracking
    - Object detection
    - Paint application allows the user to use their hand to paint on a canvas in 3-D space

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General Specifications

System Specification		
Imager	1/3 inch CMOS	
Lens Mount	CS	
Lens[1]	DP205:	55 degree FOV CS Lens with F1.2
	DP208:	80 degree FOV CS Lens with F1.2
	DP203:	30 degree FOV CS Lens with F1.2
Focus	Fixed	
IR Light Source	Integrated Light Source from laser array providing up to 1W of eye-safe (Class 1) IR light @785nm for	
	DP205:	55 degree divergence
	DP208:	80 degree divergence
	DP203:	30 degree divergence
Effective Picture Elements	64 (H) x 64 (V)	
Scanning Area	Selectable	
Synchronization	Internal, master sync output	
Scanning	Progressive	
Electronic Light Control	Power (programmable 0.1mW to 1W, 8 bits resolution) Frequency control (13MHz, 26MHz, 52MHz and 104MHz)	
Video Output	USB 1.1	
Gain Control	Programmable gain 1x, 1.3x, 2x and 4x	
AGC	None	
Electronic Shutter	64µs to 1 s with 64µs increments (14 bits)	
Frame Rate	Variable Frame Rate: 1 to 30 fps in full frames Higher frames rates for smaller windows (see formula)	
Dimensions	125mm(w) x 60mm(d) x 63mm(h)	
Power Requirement	<10W (2A@5V)	
Supply Voltage	+5VDC ±10% 100-240VAC, 50/60Hz AC Power Adapter supplied	
Extra Hole Locations	The DP200 module has features on the top and bottom so that it can be mounted robustly on a tripod.	
Cover	The system has protective covers which may be removed without affecting operation or safety level.	

[1] Values are diagonal FOV. For vertical x horizontal FOV, values are 40.5x40.5, 70x70, and 21.5x21.5 respectively for DP205, DP208, DP203

Preliminary Performance Specifications

System Performance			
Minimum and Maximum Depth & Depth Resolution at optical axis (Per pixel, per frame)	Minimum and maximum values assume optimized values for frame rate, object reflectivity, optical power, and modulation frequency at each boundary condition. These values may not be feasible for the unique characteristics of an individual application. Consult separate System Performance document for greater detail.		
		Minimum range (75% of full frame) & accuracy @ range[2]	Maximum range & accuracy at range (assumes anti-aliasing applied) [3]
	DP205:	~15cm (0.6cm std. dev.)	~12m (30cm std. dev.)
	DP203:	~50cm (1.2cm std. dev.)	~20m (30cm std. dev.)
	DP208:	~10cm (0.6cm std. dev.)	~6m (30cm std. dev.)
Depth Resolution Roll Off at the off axis regions	The average degradation of depth resolution shall not be more than 2x of the depth resolution given above.		
Dynamic Range for Range Resolution	Up to 30dB dynamic range active illumination under nominal conditions.		
SNR for Range Resolution	37 dB under nominal conditions		
Dynamic Range for Brightness	Up to 37 dB dynamic range		
Ambient Light Compensation	50W/m^2 sunlight rejection with IR filter under nominal conditions with 1W laser power.		
System Latency	<50 ms from end of shutter until data appears at the PC application		

Software Upgrade 2.0 Specifications

Software Upgrade Features	
Dynamic Range Improvement	Multiple exposures for increasing dynamic range for balanced viewing of near and far objects (Performance TBD)
Improved Resolution at Long Range	Multiple modulation frequencies and anti-aliasing within the same frame enabling high resolution at long range.

[2] White paper (reflectivity 1.0) at 30 frames per second (fps)

[3] Maximum range defined as maximum distance at which it is possible to detect movement of a human being. Accuracy figure assumes anti-aliasing, object reflectivity of 0.5, frame rate of 5fps, 1 watt light source, and modulation frequency of 50MHz.

Pricing and Availability

Getting Started with DP200

The DP200 system is available in 3 different models:

Model #	Specs	Availability
DP205	55 degree FOV	August 2004
DP203	30 degree FOV	October 2004
DP208	80 degree FOV	October 2004
DPS01	Software upgrade	TBD

Each model will include:

- Development system hardware with selected FOV
- Canesta 3D Software Development Kit (SDK)
- 90 days of email technical support in installing, configuring, and using the DP200. (Additional technical support and consulting is available for a separate fee).
- Documentation and guides for developing applications
- Sample applications

Please contact Canesta Sales (see below) for a quotation. Pricing is volume dependent. To expedite your inquiry, please include your name, your job title, your company name, a description of your application, and any other information you feel would help us to better understand your needs.

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Complies with FDA performance standards for laser products except for deviations pursuant to Laser Notice No. 50, dated 26 July 2001