Physical Sciences

4D Light Field Imaging System Using Programmable Aperture

This system would be useful for inspections and surgeries, as well as in any stereo imaging system using two cameras.

NASA's Jet Propulsion Laboratory, Pasadena, California

Complete depth information can be extracted from analyzing all angles of light rays emanated from a source. However, this angular information is lost in a typical 2D imaging system. In order to record this information, a standard stereo imaging system uses two cameras to obtain information from two view angles. Sometimes, more cameras are used to obtain information from more angles. However, a 4D light field imaging technique can achieve this multiple-camera effect through a single-lens camera.

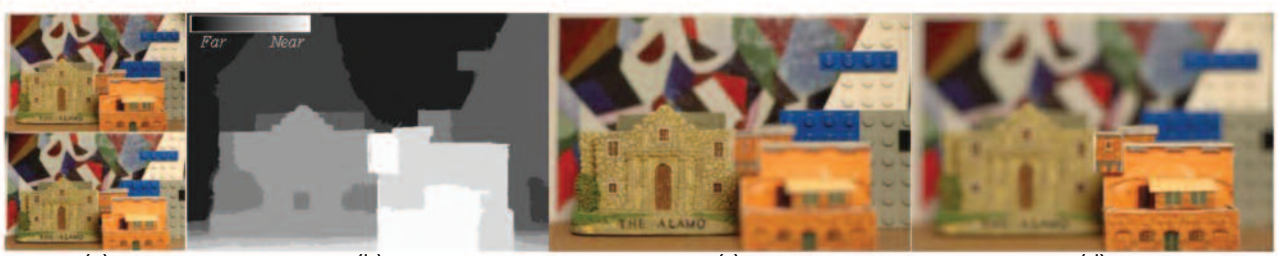
Two methods are available for this: one using a microlens array, and the other using a moving aperture. The moving-aperture method can obtain more complete stereo information. The existing literature suggests a modified liquid crystal panel [LC (liquid crystal) panel, similar to ones commonly used in the display industry] to achieve a moving aperture. However, LC panels cannot withstand harsh environments and are not qualified for spaceflight. In this regard, different hardware is proposed for the moving aperture.

A digital micromirror device (DMD) will replace the liquid crystal. This will be qualified for harsh environments for the 4D light field imaging. This will enable an imager to record near-complete stereo information.

The approach to building a proof-of-concept is using existing, or slightly modified, off-the-shelf components. An SLR (single-lens reflex) lens system, which typically has a large aperture for fast imaging, will be modified. The lens system will be arranged so that DMD can be integrated. The shape of aperture will be programmed for single-viewpoint imaging, multiple-viewpoint imaging, and coded aperture imaging.

The novelty lies in using a DMD instead of a LC panel to move the apertures for 4D light field imaging. The DMD uses reflecting mirrors, so any light transmission lost (which would be expected from the LC panel) will be minimal. Also, the MEMS-based DMD can withstand higher temperature and pressure fluctuation than a LC panel can. Robotics need near complete stereo images for their autonomous navigation, manipulation, and depth approximation. The imaging system can provide visual feedback.

This work was done by Youngsam Bae of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48604



(a) Two demultiplexed light field images generated by the **4D Light Field Imaging System**. The full 4D resolution is 4×4×3039×2014. (b) The estimated depth map of the top image of (a). (c, d) Post-exposure refocused images generated from the light field and the depth maps.

Device and Container for Reheating and Sterilization

This device can be used for packaged products that require heating prior to use.

Lyndon B. Johnson Space Center, Houston, Texas

Long-duration space missions require the development of improved foods and novel packages that do not represent a significant disposal issue. In addition, it would also be desirable if rapid heating technologies could be used on Earth as well, to improve food quality during a sterilization process. For this purpose, a package equipped with electrodes was developed that will enable rapid reheating of contents via ohmic heating to serving temperature during space vehicle transit. Further, the package is designed with a resealing feature, which enables the package, once used, to contain and sterilize waste, including human waste for storage prior to jettison during a long-duration mission.

Ohmic heating is a technology that has been investigated on and off for over a century. Literature indicates that foods processed by ohmic heating are of superior quality to their conventionally processed counterparts. This is due to the speed and uniformity of ohmic heating, which minimizes exposure of sensitive materials to high temperatures. In principle, the material may be heated rapidly to sterilization conditions, cooled rapidly, and stored.

The ohmic heating device herein is incorporated within a package. While this by itself is not novel, a reusable feature also was developed with the intent that waste may be stored and re-sterilized within the packages. These would then serve a useful function after their use in food processing and storage.

The enclosure should be designed to minimize mass (and for NASA's purposes, Equivalent System Mass, or ESM), while enabling the sterilization function. It should also be electrically insulating. For this reason, Ultem® high-strength, machinable electrical insulator was used.

Because the pouch would expand when exposed to heating to sterilization temperatures (greater than 121 °C), it is necessary to prevent seal rupture by applying air pressure into the enclosure. To enable cooling of the package in the enclosure, a water inlet and outlet are provided. The electrode tabs could be modified to form a larger pair of electrodes, which will also allow heating of water within the enclosure if necessary.

Under normal reheating conditions, temperatures will not need to go above 100 °C, thus the air overpressure feature will be unnecessary. The plan is to provide a user interface with a keypad that will enable users to dial in the heating protocol depending on the product that is within the chamber. This feature could be automated.

The incidence of electrolysis will be minimized using a solid-state IGBT power supply at 10 kHz. This is critical in a space application, since bubble formation at the electrodes can stop the heating unless electrolysis can be suppressed.

This work was done by Sudhir K. Sastry, Brian F. Heskitt, Soojin Jun, Joseph E. Marcy, and Ritesh Mahna of Ohio State University for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

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Refer to MSC-23999-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Radio Frequency Plasma Discharge Lamps for Use as Stable Calibration Light Sources

Electrode-induced instabilities are eliminated and the lifetime is not limited by electrode erosion.

Goddard Space Flight Center, Greenbelt, Maryland

Stable high radiance in visible and near-ultraviolet wavelengths is desirable for radiometric calibration sources. In this work, newly available electrodeless radio-frequency (RF) driven plasma light sources were combined with research-grade, low-noise power supplies and coupled to an integrating sphere to produce a uniform radiance source. The stock light sources consist of a 28 VDC power supply, RF driver, and a resonant RF cavity. The RF cavity includes a small bulb with a fill gas that is ionized by the electric field and emits light. This assembly is known as the emitter. The RF driver supplies a source of RF energy to the emitter.

In commercial form, embedded electronics within the RF driver perform a continual optimization routine to maximize energy transfer to the emitter. This optimization routine continually varies the light output sinusoidally by approximately 2% over a several-second period. Modifying to eliminate this optimization eliminates the sinusoidal variation but allows the output to slowly drift over time. This drift can be minimized by allowing sufficient warm-up time to achieve thermal equilibrium. It was also found that supplying the RF driver with a low-noise source of DC electrical power improves the stability of the lamp output. Finally, coupling the light into an integrating sphere reduces the effect of spatial fluctuations, and decreases noise at the output port of the sphere.

The RF-driven lamps have several advantages over traditional calibration sources. Currently, accurate radiance measurements can be made at infrared and the red portion of the visible wavelengths using tungsten filament-style FEL lamps. However, the blackbody output of these lamps is limited to 3,000 K, and intensity falls exponentially at shorter wavelengths at the blue end of the spectrum. For reproduction of the solar spectrum, with an equivalent blackbody temperature of 6000 K, the blue and ultraviolet wavelengths have typically been produced using high-pressure xenon arc discharge lamps. These lamps achieve the high temperature necessary in a narrow filament of ionized gas between two electrodes. This ion channel suffers from instabilities produced by buoyancy-induced turbulence of the surrounding gas. There is also longer-term drift associated with the sputtering of electrode material through ion impact, which changes both the electrode spacing and surface profile. Due to the high electric field gradients, these small changes in geometry result in non-negligible changes to the light output.

Additionally, much of the sputtered electrode material is deposited as a thin layer on the inner surface of the lamp. This decreases light transmission through the glass and ultimately limits the useful life of the lamp to no more than 1,000 hours, over the course of which the radiant flux may decrease by a factor of two. Additionally, the xenon lamps generate several undesirable sharp emission lines with large intensity variation over a small spectral range. The electrode-induced instabilities are eliminated in the RF lamp, and the lifetime is not limited by electrode erosion. The higher operating pressure of the RF-driven bulbs produces a smoother broadband spectrum. The RF lamps are also more efficient, and have more conducive geometry for coupling their light into an integrating sphere.

This work was done by Brendan McAndrew and John Cooper of Goddard Space Flight Center; and Angelo Arecchi, Greg McKee, and Christopher Durell of Labsphere, Inc. Further information is contained in a TSP (see page 1). GSC-16399-1