Sensors on 3D Digitization

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Abstract: ***This paper presents our activities on smart VLSI opto-sensors for 3D vision. A description of the integrated devices jointly developed for industrial and scientific applications is given. All the sensors presented here have been fabricated using standard CMOS technology that allows the monolithic integration of photo-sensors, together with readout circuits, and digital signal processors.***

Keywords: VLSI, 3D Vision

1. Introduction

Digital 3D imaging can benefit from advances in VLSI technology in order to accelerate its deployment in many fields like visual communication and industrial automation. High-resolution 3D images can be acquired using laser-based vision systems. With this approach, the 3D information becomes relatively insensitive to background illumination and surface texture. Complete images of visible surfaces that are rather featureless to the human eye or a video camera can be generated. Intelligent digitizers will be capable of measuring accurately and simultaneously color and 3D.

Machine vision involves the analysis of the properties of the luminous flux reflected or radiated by objects. To recover the geometrical structures of these objects, either to recognize or to measure their dimension, two basic vision strategies are available.

Passive vision, attempts to analyze the structure of the scene under ambient light. Stereoscopic vision is a passive optical technique. The basic idea is that two or more digital images are taken from known locations. The images are then processed to find the correlations between them. As soon as matching points are identified, the geometry can be computed.

Active vision attempts to reduce the ambiguity of scene analysis by structuring the way in which images are formed. Sensors that capitalize on active vision can resolve most of the ambiguities found with two dimensional imaging systems. Lieder based or triangulation based laser range cameras are examples of active vision technique. One digital 3D imaging system based on optical triangulation were developed and demonstrated

2. History

Sensors have been around for quite some time in various forms. The first thermostat came to market in 1883, and many consider this the first modern, manmade sensor. Infrared sensors have been around since the late 1940s, even though they've really only entered the popular nomenclature over the past few years. Motion detectors have been in use for a number of years. Although wireless sensor nodes have existed for decades and used for applications as diverse as earthquake measurements to warfare, the modern development of small sensor nodes dates back to the 1998 Smart dust project and the NASA Sensor Webs Project. One of the objectives of the Smart dust project was to create autonomous sensing and communication within a cubic millimeter of space. Though this project ended early on, it led to many more research projects. They include major research centers in Berkeley NEST and CENS. The researchers involved in these projects coined the term mote to refer to a sensor node. The equivalent term in the NASA Sensor Webs Project for a physical sensor node is pod, although the sensor node in a Sensor Web can be another Sensor Web itself. Physical sensor nodes have been able to increase their capability in conjunction with Moore's Law. The chip footprint contains more complex and lower powered microcontrollers. Thus, for the same node footprint, more silicon capability can be packed into it. Nowadays, motes focus on providing the longest wireless range (dozens of km), the lowest energy consumption (a few uA) and the easiest development process for the user.

3. Construction

3.1 Auto-synchronized Scanner

The auto-synchronized scanner, depicted schematically on Figure 1, can provide registered range and colour data of visible surfaces. A 3D surface map is captured by scanning a laser spot onto a scene, collecting the reflected laser light, and finally focusing the beam onto a linear laser spot sensor. Geometric and photometric corrections of the raw data give two images in perfect registration: one with *x*, *y*, *z* co-ordinates and a second with reflectance data. The laser beam composed of multiple visible wavelengths is used for the purpose of measuring the colour map of a scene (reflectance map).

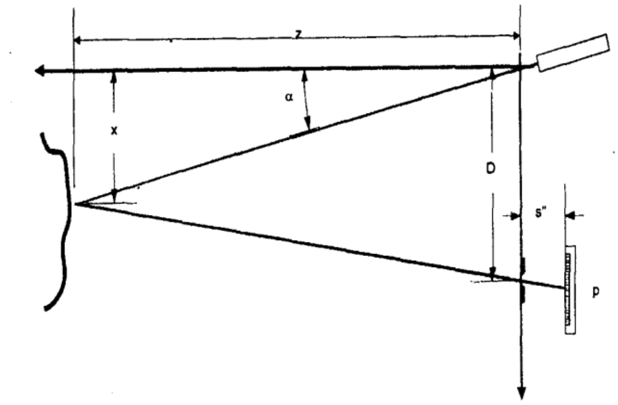

Figure 1: Scanning diagram

3.2 Sensors for 3D imaging

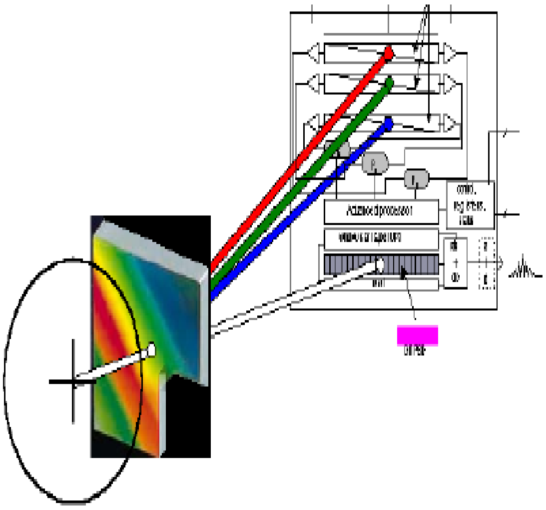

Figure 2: Image with circuit

A 3D surface map is captured by scanning a laser spot onto a scene, collecting the reflected laser light from a different vantage point (triangulation). An object is illuminated by a collimated RGB laser spot and a portion of the reflected radiation upon entering the system is split into four components by a diffracting optical element as shown in figure 4b. The white *zero order* component is directed to the DRPSD, while the RGB 1storder components are directed onto three CRPSD, which are used for colour detection. The CRPSDs are also used to find the centroid of the light distribution impinging on them and to estimate the total light intensity The centroid is computed on chip with the well-known current ratio method i.e. (I1-I2)/ (I1+I2) where I1 and I2 are the currents generated by that type of sensor. [3] The weighed centroid value is fed to a control unit that will select a sub-set (window) of contiguous photo-detectors on the DRPSD. That sub-set is located around the estimate of the centroid supplied by the CRPSD. Then, the best algorithms for peak extraction can be applied to the portion of interest. finally focusing the beam onto a position detector. A similar geometry can be based upon the projection of a laser line instead of a single laser spot. Geometric correction of the raw data gives two images in perfect registration: one with *x*, *y*, *z* co-ordinates and a second with intensity data representing the collected laser power from the scene

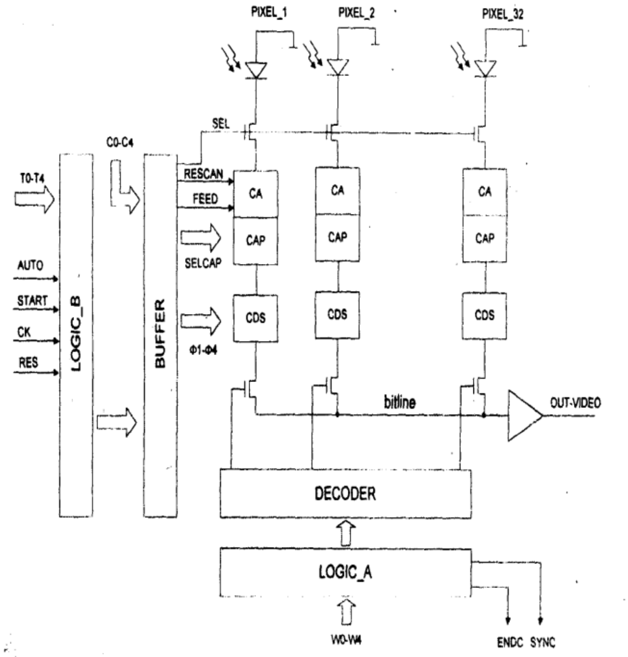

Figure 3: Block diagram of 3D Digitization.

4. Advantages

- Reduced size and cost
- Better resolution at a lower system cost
- High reliability that is required for high accuracy 3D vision systems
- Complete images of visible surfaces that are rather featureless to the human eye or a video camera can be generated.

5. Disadvantages

- The elimination sophisticated techniques of all stray light in an optical system requires

6. Applications

- Intelligent digitizers will be capable of measuring accurately and simultaneously colour and 3D
- For the development of hand –held 3D cameras
- Multi resolution random access laser scanners for fast search and tracking of 3D features

7. Future Scopes

Anti reflecting coating film deposition and RGB filter deposition can be used to enhance sensitivity and for colour sensing

8. Conclusion

The results obtained so far have shown that optical sensors have reached a high level of development and reliability those are suited for high accuracy 3D vision systems. The availability of standard fabrication technologies and the acquired know-how in the design techniques, allow the implementation of optical sensors that are application specific: Opto-ASICs. The trend shows that the use of the low cost CMOS technology leads competitive optical sensors. Furthermore post-processing modules, as for example anti reflecting coating film deposition and RGB filter deposition to enhance sensitivity and for colour sensing, are at the final certification stage and will soon be available in standard fabrication technologies. The work on the Color range is being finalized and work has started on a new improved architecture.

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