A Design of Digital Image Sensor Based on UWB

[1]Dr. G.Natarajan, [2]B.Karthiga, [3]N.Kannan
[1]Professor & Head, [2]Associate Professor, [3]Assistant Professor,
[1]Department of Physics, [2]Department of ECE, [3]Department of ECE,
[1]PSNA college of Engineering, [2]Srinivasan Engineering, [3]Dhanalakshmi Srinivasan
and Technology, College, Engineering College, Dindigul-624622, Perambalur-621212, TamilNadu.

Abstract

A low power temporal-difference image sensor with wireless communication capability designed specifically for imaging sensor networks. The event-based image sensor features a 64 X 64 pixel arrays that capture and compressed the motion based images and compute the temporal difference images, while continuously monitoring for photocurrent changes. An ultra-wide-band radio channel allows transmitting digital temporal difference images wirelessly to a receiver with high rates and reduced power consumption. The sensor can enable the UWB when it detects a specific number of pixels intensity modulations, so that only significant frames are communicated. By the help of encoding technique the error rate is reduced up to 10% compared to previous work.

Keywords: Image sensor, motion detection, temporal-difference, Ultra-Wide-Band (UWB), wireless sensor network.

I. Introduction

Image processing involves more computation and memory intensive tasks. Energy efficiency is the primary concern on the choice of image compression. In the selection of data encoding strategy trade-offs should be taken among scanning and asynchronous address event readout approaches. In each and every pixel independently and in continuous time quantizes local relative intensity changes to generate spike events. Pixel events are queued and wait for their turn for access to a shared arbitrated bus and appear at the output as an asynchronous stream of digital pixel addresses (15 bit/pixel) which is known as address events. The sensor performs on-chip contrast extraction and off-chip temporal detection.

Instead of asynchronous address event (AE), a sequential scanning readout scheme is used in this work to reduce the bandwidth requirement. This design choice is derived from the number of bits required to represent each event which is 1 using scanning approach while 13 using AE format for a 64x 64 imager. The percentage threshold will be lower when the resolution of the imager grows.

The event rate of a temporal motion detector in this design requires 1–10 Mbps data rate while the power consumption should be at ~ 10 mW levels. Ultra Wide Band (UWB) is drawing much attention from both academia and industry. Its performance in low power and high speed in short range wireless communications makes it the ideal candidate. Also without template pulse generator and quadrature frequency synthesizer the transmission unit is enter into the sleep mode during large percentage of operation. This will significantly reduce the system power consumption by taking advantage of the low-duty cycling property of temporal difference sensor output.

With the above considerations design a wireless image sensor that capture and compressed motion-based temporal difference digital images and is capable of transmit the data wirelessly by means of an ultra-low power high-bandwidth radio based on ultra-wide-band pulse radio communication. The sensor performs temporal-difference calculations between frames while continuously monitoring

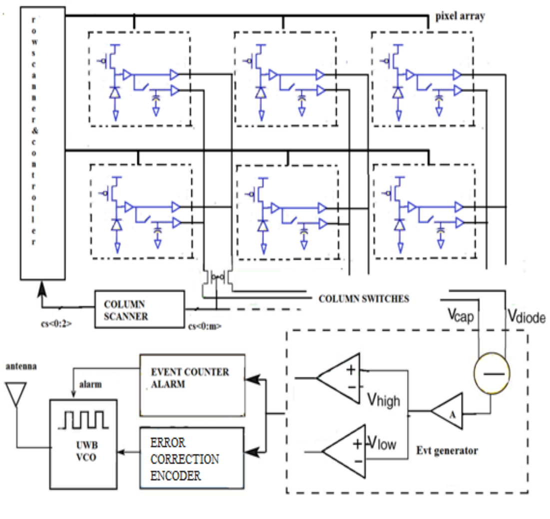

Fig.1.Block diagram of the wireless image sensor

for photocurrent changes. Each pixel responds with a binary event that represents whether a fractional increase/decrease in intensity that exceeds a tunable threshold (ONE) or not (ZERO). Therefore moving objects (ONE pixels) can be easily identified out of the static, whatever complicated background (ZERO pixels). In the next stage, the binary event stream is modulated by the Error correction Encoder and UWB transmitter. The wireless data link is based on a non-coherent UWB impulse radio. The main innovative contribution of this work is the seamless integration of a motion detection sensor and ON/OFF keying UWB radio enabling a custom low power and high frame wireless sensor node for applications such as assisted living monitors security cameras and robotic vision.

II. Temporal Difference Imager

A. Imager architecture

Fig.1 reports the system diagram of the autonomous sensor. Main building blocks include an array of 64x64 pixels, global event generator, error correction encoder, UWB transmitter and row and column scanners. Each pixel is equipped with an analog memory (capacitor) and the whole array is hence capable of storing the current frame as a reference image. The rows are first sequentially selected for reset. Later at another round of scanning the rows of pixels are selected for readout sequentially. Each pixel will output both the new integration voltage on its photodiode and the previous voltage stored on its capacitor.

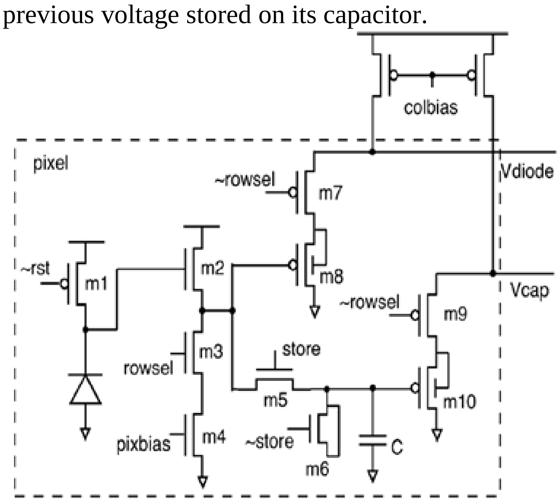

Fig.2. Schematic of the pixel

The two voltages are fed into a global event generator circuit which is composed of a global amplifier with a temporal-difference computation circuit based on dual comparison.

The event generator computes the difference between the two voltages, and compares it with a positive and negative threshold. A digital event is generated if this difference exceeds the thresholds. The event bit stream together with the clock is first encoded by a error correction encoder circuit. The encoded digital code is converted into an impulse sequence in the UWB transmitter.

A simple but efficient wireless power saving scheme is built in the imager. An on-chip 12-bit counter monitors the number of events per frame and will generate an “alarm” signal when that number exceeds a programmable threshold. Only when the “alarm” signal is triggered the UWB transmitter circuit will be enabled to transmit the events of the next frame.

Most of the time the wireless part is in standby mode for saving power. Bias voltages which are internally generated are used to operate the sensor and there is no need for external biasing DAC.

B. Pixel Design and readout

Fig.2 shows the block diagram of the proposed pixel. Each pixel includes a photosensitive element (photodiode), a reset transistor (m_1) a source follower (m_2–m_4) a sample-and-hold path composed of (m_5) and two sets of readout circuits (m_7–m_8 andm_9–m_{10}). Transistor m_3 is used as a power saving device to turn OFF the source follower path when the pixel is not selected for any operation. P-type MOS transistors are used in the readout source follower circuits (m_7, m_8 and m_9–m_{10}) to compensate the DC level shift due to the N-type source follower (m_2). They are fabricated in dedicated N-Wells with bulk voltage tied to the source nodes to reduce body effect.

The pixel’s operation follows a sequence of reset, integration, readout, sample-and-hold and reset. First a reset operation is performed and transistor (m_1) is turned ON initializing the photo detector to the power supply voltage. Then the transistor (m_1) is turned OFF and the integration phase starts. At the end of the integration phase the pixel is selected for readout by the ~rowsel signal. Both the new integration voltage on the photo detector and the stored voltage on the capacitor will be read. After that, sample and hold operation will be performed. (m_5) will be on and the current integration voltage will be stored on the capacitor overwriting the old value.

One may also note that in readout operation the pixels are selected in a column by column manner while in sample and hold and reset operation the whole row of pixels are selected in parallel. This is due to the absence of column selection switches in each pixel which leads to reduced pixel area and column bus routing resource but at the expense of minor column-wise integration time mismatch.

C. Event Generation.

The two pixel output voltages, one from the photodiode (Vdiode) and the other from the capacitor (Vcap) are copied onto two column-wise buses and their difference is computed. The two voltages are fed into a global event generator circuit which is composed of a global amplifier with a temporal-difference computation circuit based on dual comparison shown on fig 3.

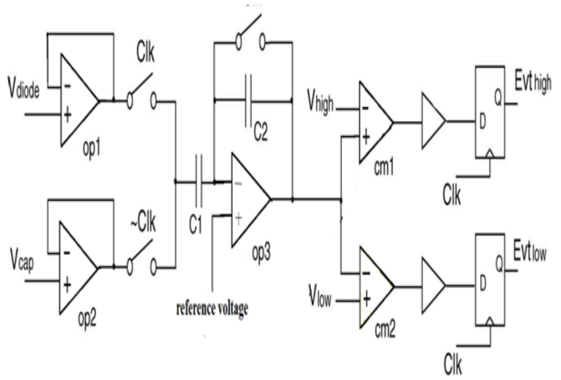

Fig.3.Event Generation circuit

The operational amplifiers op1–op3 are based on the same architecture but designed with different gain-band width product. The output signal from the differentiator centered on (*vdd*/2).After the comparison between the two voltages with the programmable threshold voltage. A digital event is generated if this difference exceeds the threshold and finally the V_{high} and $V_{low.}$ Voltages are converted into the corresponding digital events in the digital signal sampling circuits (Evt_{high} ,Evt_{low})

III. UWB wireless transmission.

In the UWB transmission unit which contains clock and data encoding pulse modulation, pulse detection, clock and data recovery shown in fig.4. The integrated transmitter first feeds the event bit stream and clock into the encoder circuit.

The encoded digital signal is converted into an impulse sequence in the UWB transmitter. The transmitter generates impulses using a voltage controlled oscillator and operates in the on/off keying mode. The ON/OFF keying mode is used to save the power. When the transmission units enter into the sleep mode the key is switched into off modes which save power.

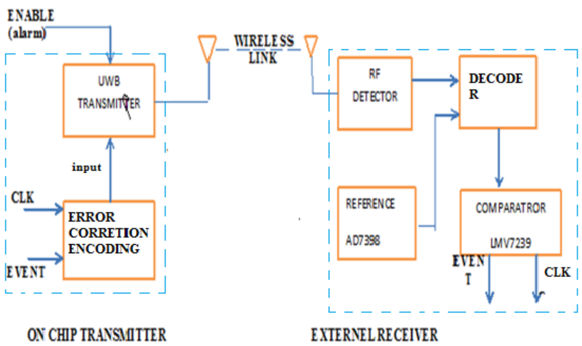

Fig.4.Blocks of the wireless data link of the whole system

The transmitter generates impulses using a voltage controlled oscillator and operates in the ON/OFF keying mode. One can note that the transmitter can be set to standby mode and consume no power. It is only active when significant amount of motion pixels detected by the alarm generator. In existing system Manchester encoder is used to achieve each single bit of clock and data recovery over the wireless link. After encoding each code bit will have at least one transition and occur at the same time. Though it is simple and employed for its low cost the major disadvantage in it is more bits are transmitted than the original signal and it require higher bandwidth. In this work forward error correction encoding is used that enable reliable delivery of digital data over unreliable communication.

IV. Results and Discussions

In order to simulate the technique proposed in this paper the error rate is decreased. Error control coding techniques detect and possibly correct errors that occur during transmission. To accomplish this, the encoder transmits not only the information signals but also one or more redundant symbols. The decoder uses the redundant symbols to detect and possibly correct whatever errors occurred during transmission. In Manchester encoding the error rate is 0.26%.when we use forward error correction coding the error rate is decreased up to 10%. In 3584 slices the design uses only 168 slices therefore only it utilizes 4% of the total space.

IV. Conclusion

The main innovative of this work is the seamless integration of a motion detection and on/off keying UWB channel which enabling a custom low power and high frame rate.UWB wireless channel consumes less than 15 mW when operating at 160 frames/s and 1.3Mbps.In particular the wireless link can turn to standby mode when there is little motion in the sense. It can be reactivated when the on-chip alarm generator detects enough motion that exceeds a programmable threshold. Instead of Manchester encoder in this work forward error correction encoding is used and it is suitable for the unreliable communication. Therefore the sensor can serve as an ultra-low power trigger to external high-resolution cameras for taking timely snapshots. This is an ideal candidate of wireless sensor network node for applications such as assisted living monitors, security cameras and even robotic vision.

References

[1] K.Y.Min and J.W.Chon, "A real-timejpeg encoder for 1.3 megapixel CMOS image sensor SOC," in *Proc. IEEE 30th Annu. Conf. Ind.Electron. Soc.*, 2004, pp. 2633–2636.

[2] Y.Nishikawa, S.Kawahito, M.Furuta, and T. Tamura, "A high-speedCMOS image sensor with on-chip parallel

image compression circuits," in *Proc. IEEE Custom Integr.CircuitsConf.*, 2007, pp.833–836.

[3] A.Nilchi, J.Aziz, and R.Genov, "Focal-plane algorithmically-multiplyingCMOS computational image sensor," *IEEE J. Solid-State Circuits*,vol. 44, pp. 1829–1839, Sep. 2009.

[4] S.Chen, A. Bermak, and Y. Wang, "A CMOS image sensor withon-chip image compression based on predictive boundary adaptation and memory less QTD algorithm," *IEEE Trans. Very Large ScaleIntegr. (VLSI) Syst.*, vol. 19, no. 4, pp. 538–547, Apr. 2011.

[5] P.Lichtsteiner, C.Posch & T. Delbruck, "A 128x128 120db 15μs latency asynchronous temporal contrast vision sensor," *IEEE J. Solid-State Circuits*, vol. 43, no. 2, pp. 566–576, Feb. 2008.

[6] M. Gottardi, N. Massari& S. A. Jawed, "A 100μW 128x64pixels contrast-based asynchronous binary vision sensor for sensor networks applications," *IEEE J. Solid-State Circuits*, vol. 43, no. 5, pp.1582–1592, May 2009.

[7] E. Culurciello, R. Etienne-Cummings, and K. Boahen, "Arbitrated address event representation digital image sensor," in *Proc. IEEE Int.Solid-State Circuits Conf.*, 2001, pp. 92–93

[8] S. B. T. Wang, A. M. Niknejad, and R. W. Brodersen, "Design of a sub-MW 960-MHz UWB CMOS LNA," *IEEE J. Solid-State Circuits*,vol. 41, no. 11, pp. 2449–2456, Nov. 2006

[9] T.-A. Phan and S.-G. Lee, "Low-power CMOS energy detection transceiver for UWB impulse radio system," in *Proc. IEEE CustomIntegr. Circuits Conf.*, 2007, pp. 675–678

[10] V. Gruev and R. Etienne-Cummings, "A pipelined temporal difference imager," *IEEE J. Solid-State Circuits*, vol. 39, no. 3, pp. 538–543, Mar.2004.

[11] U.Mallik,M. Clapp, E. Choi, G. Cauwenberghs, and R. Etienne-Cummings, "Temporal change threshold detection imager," in *Proc. IEEEInt. Solid-State Circuits Conf.*, 2005, pp. 362–603.

[12] A. Chandrakasan, F. Lee, D. Wentzloff, V. Sze, B. Ginsburg, P.Mercier, D. Daly, and R. Blazquez, "Low-power impulse UWB architectures and circuits," *Proc. IEEE*, vol. 97, no. 2, pp. 332–352,Feb. 2009.

[13] A. Dickinson, B. Ackland, E.-S. Eid, D. Inglis, and E. Fossum, "A 256x256 CMOS active pixel image sensor with motion detection," in*Proc. IEEE Int. Solid-State Circuits Conf.*, 1995, pp. 226–227.

[14] W. Tang and E. Culurciello, "A low-power high-speed ultra-wide band pulse radio transmission system*Syst.*, 2008, pp. 1064–1067.," *IEEE Trans. Biomed. Circuits Syst.*, pp. 286–292, 2009.

[15] Jaein Jeong and Cheng Tien Ee, "Forward error correction in sensor networks, in *University of California., Berkeley"* May 16-2003.