A Simulation System for Signal Readout of CMOS Pixel Sensors in High Energy Physics experiments

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Signal Readout of CMOS Pixel Sensors

In order to achieve extreme high readout speed and low power consumption, many researches are focused on data sparsification and data compression during the signal readout.

Applications of the Simulation system

High speed readout systems:
- Signal compressed during readout
- Signal readout related with the hit number and distribution

Classical Readout:
- Data compressed after readout
- Readout performances depends on the size of pixel array.

A simulation system with proper input particle images will be helpful for high speed and low power readout system design.

Simulation System

Flow of simulation

Define an imaging matrix and initializes the parameters including:
- Size of pixel array: M, N
- Frames of imaging: K
- Hit number distribution: \( \text{hit}_\text{hit}, \text{hit}_\text{miss} \)
- The number of one hit: \( \text{hit}_\text{hit}, \text{hit}_\text{miss} \)
- The amplitude for one hit: \( \text{amp}_\text{hit}, \text{amp}_\text{miss} \)

Obtain an initial matrix (empty or with noise)

Generate the number of hits (H)

Generate H hits with Random uniform distribution

Obtain the coordinates and amplitudes of H hits

Generate the scales of the fired pixels with Gaussian random number

Generate the matrix representing the amplitude of the fired pixels according Luminance distribution

Obtain H matrices representing the fired amplitude of H hits

Obtain a frame of imaging data by inserting the H hits into the initial matrix

K frame data?

The simulation system can well generate particle images.

Applications of the Simulation system

- According to the readout strategies of the CPS, we can utilize the simulation system for characterization of the data in the matrix and for the evaluation of data recovery efficiency.
- In advance, the simulation system can be used for studying other readout strategies, such as compressive sensing readout.

Simulation results of Orthopix:
The detection efficiency of Orthopix design is simulated with various images of different signal cluster sizes, signal distribution and signal occupancy. The results are consistent with [3]. This recovery efficiency is high enough for small cluster and ultra low occupancy. In advance, the efficiency is simulated for some other cases. The efficiency is sharply decrease when the number of hits larger than 30 in an matrix of 1024 \times 1024 with cluster size of 4.

Reference