Image Sensor: Pi Camera!

Juan Medina - Summer 2015
Outline: what you might learn

● **Digital Cameras**
  ○ History (Mariner 4) and connectivity/social impact

● **What is an image sensor?**
  ○ Types
  ○ Color separation and Performance metric

● **Pi Camera:**
  ○ purpose, price, datasheet!

● **Example and Conclusions**
History and Social Impact

Infinite eyes to see the world
What’s an Image Sensor?

Functionality, types, performance metrics
I’ll be very quick on this one....
Modern sensors:
CCDs, CMOS
CCDs
Charged Coupled Devices
CCDs
Charged Coupled Devices

CCD Sense Element (Pixel) Structure

Integration of Photon-Induced Charge
Parallel Bucket Array

Parallel Register Shift (1 Row)
Serial Register Shift to Output

Bucket Brigade CCD Analogy
CMOS
Complementary metal–oxide–semiconductor

[CMOS Sensor]

Photodiode
Amplifier
Metal wire
Signal output
CMOS
Complementary metal–oxide–semiconductor
Color Separation:
Bayer filter pattern
Performance Metrics
- **Pixel count**
  - total number of pixels
- **Lens quality**
  - resolution, distortion, dispersion.
- **Dynamic range**
  - the range of luminosity that can be reproduced accurately.
Pi Camera

Purpose, price, datasheet, examples
Pi Camera: Raspberry Pi Price
Pi Camera:
QV5647 Datasheet
Pi Camera: Datasheet

features

- 1.4 μm x 1.4 μm pixel with OmniBSI technology for high performance (high sensitivity, low crosstalk, low noise)
- optical size of 1/4"
- automatic image control functions: automatic exposure control (AEC), automatic white balance (AWB), automatic band filter (ABF), automatic 50/60 Hz luminance detection, and automatic black level calibration (ABLC)
- programmable controls for frame rate, AEC/AGC 16-zone size/position/weight control, mirror and flip, cropping, windowing, and panning
- image quality controls: lens correction, defective pixel canceling
- support for output formats: 8-/10-bit raw RGB data
- support for video or snapshot operations

- support for LED and flash strobe mode
- support for internal and external frame synchronization for frame exposure mode
- support for horizontal and vertical sub-sampling
- standard serial SCCB interface
- digital video port (DVP) parallel output interface
- MIPI interface (two lanes)
- 32 bytes of embedded one-time programmable (OTP) memory
- on-chip phase lock loop (PLL)
- embedded 1.5V regulator for core power
- programmable I/O drive capability, I/O tri-state configurability
- support for black sun cancellation
Pi Camera: Datasheet

key specifications

- active array size: 2592 x 1944
- power supply:
  - core: 1.5V ± 5% (with embedded 1.5V regulator)
  - analog: 2.6 ~ 3.0V (2.8V typical)
  - I/O: 1.7V ~ 3.0V
- power requirements:
  - active: TBD
  - standby: TBD
- temperature range:
  - operating: -30°C to 70°C (see table 8-2)
  - stable image: 0°C to 50°C (see table 8-2)
- output formats: 8-/10-bit RGB RAW output
- lens size: 1/4"
- lens chief ray angle: 24° (see figure 10-2)
- input clock frequency: 6~27 MHz
- S/N ratio: TBD
- dynamic range: TBD
- maximum image transfer rate:
  - QSXGA (2592 x 1944): 15 fps
  - 1080p: 30 fps
  - 960p: 45 fps
  - 720p: 60 fps
  - VGA (640 x 480): 90 fps
  - QVGA (320 x 240): 120 fps
- sensitivity: TBD
- shutter: rolling shutter / global shutter
- maximum exposure interval: 1968 x t\text{ROW}
- pixel size: 1.4 μm x 1.4 μm
- well capacity: TBD
- dark current: TBD
- fixed pattern noise (FPN): TBD
- image area: 3673.6 μm x 2738.4 μm
- die dimensions: 5520 μm x 4700 μm
Pi Camera: Datasheet
Example

Garbage classification
Solid Waste Characterization Project

Input Image

Histogram Of Oriented Gradients
Conclusions

- Digital Cameras
  - History (Mariner 4) and connectivity/social impact
- What is an image sensor?
  - Types
  - Color separation and Performance metric
- Pi Camera:
  - purpose, price, datasheet!
- Example and Conclusions