# Role of CMOS Image Sensors based Surveillance Systems in Demanding Fields

**Susrutha Babu Sukhavasi , Suparshya Babu Sukhavasi,**
**Advisor: Dr. Khaled Elleithy ,Co-Advisor: Dr Abdel Abuznied**
**Department of Computer Science and Engineering**
**University of Bridgeport, Bridgeport, CT**

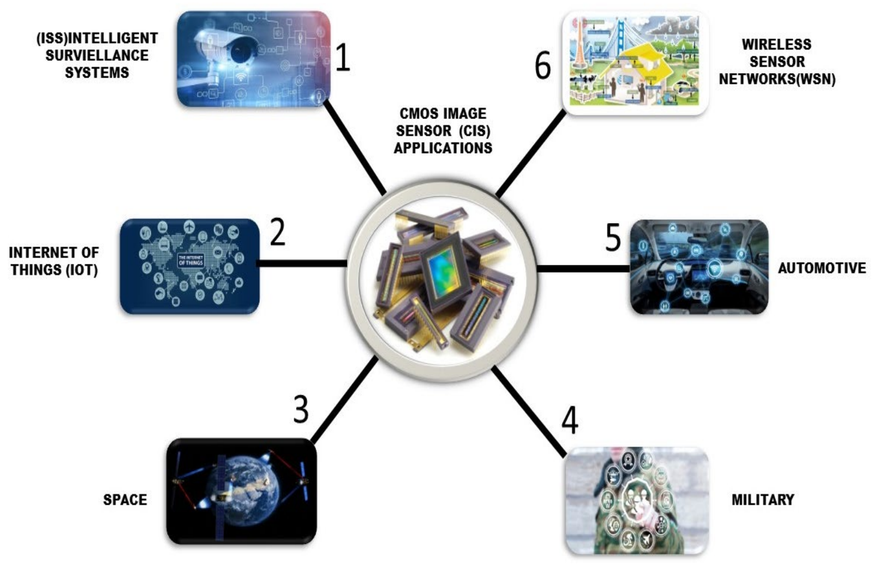
## Abstract

Our research currently focusing on image sensors predominantly the sensors implemented using CMOS (Complementary Metal Oxide Semiconductor) technology. Recent technology advances in CMOS image sensors (CIS) enable their utilization in the most demanding surveillance fields, especially visual surveillance and intrusion detection in intelligent surveillance systems, aerial surveillance in war zones, Earth environmental surveillance by the satellites in space monitoring, agricultural monitoring using wireless sensor networks and internet of things and driver assistance in automotive fields. We present an overview of CMOS image sensor-based surveillance applications over the last decade by tabulating the design characteristics related to image quality such as resolution, frame rate, dynamic range, signal-to-noise ratio, and also processing technology. Year wise usage of CIS models are represented.

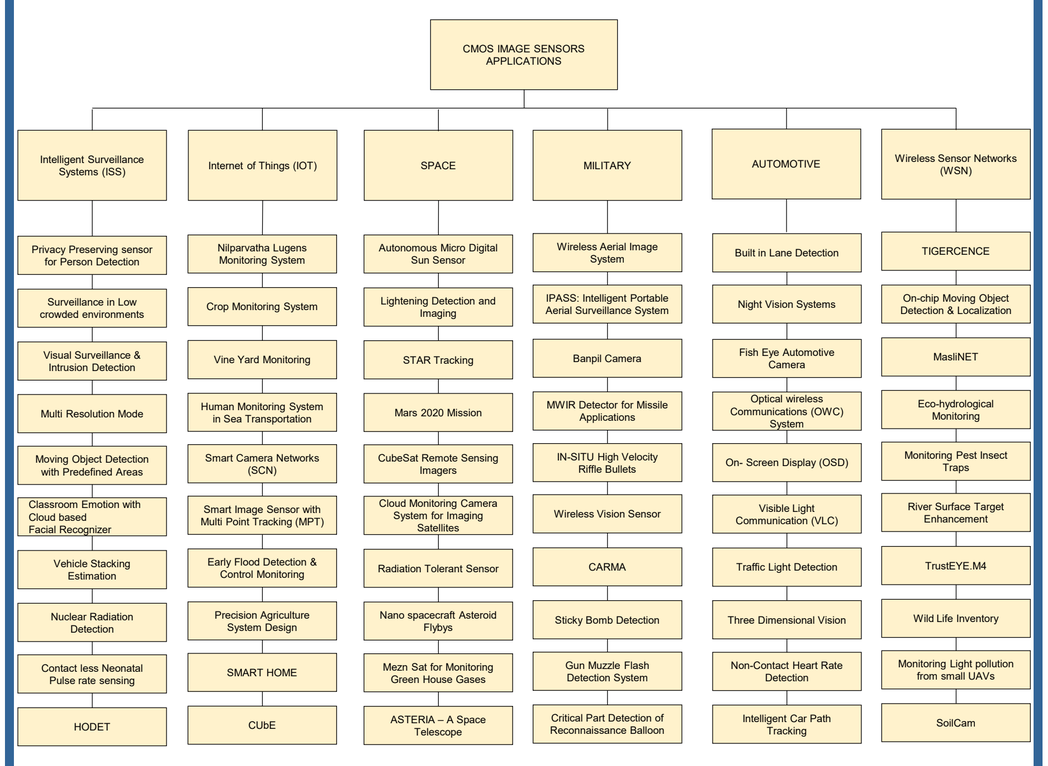
**Keywords:** CMOS image sensor; surveillance systems; resolution; dynamic range; frame rate; signal to-noise ratio

## Introduction

Nowadays, humankind is more dependent on technology, especially in automotive, military, space, wireless sensor networks, and the internet of things for surveillance purposes. To make life easier, these fields have used a lot of convenient methods. We need to think of imaging technology for emerging imaging systems in all the mentioned applications over the past decade. The improvements and advancements are still going on to miniaturize these applications with high speed and high performance for incorporation in a micro area. Due to their amazing performance advantages over CCDs, CMOS image sensors (CIS) have grabbed huge attention in most applications from the past decade. To explain CIS's significance, we herein presented the surveillance systems in six demanding fields in which applications were developed using CIS.




Applications of CMOS IMAGE SENSOR as surveillance system in various fields.

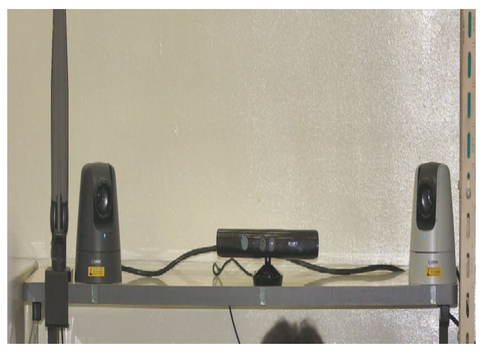



Classification of CMOS image sensor based applications in various fields for surveillance

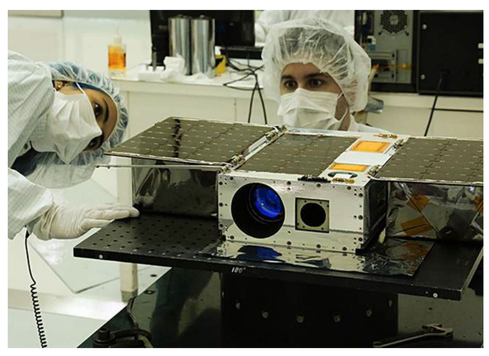
The CIS is implemented in the following applications like HODET in Intelligent Surveillance Systems, 3D Ranging Camera in Automotive, KINECT-KII in Internet Of Things, CUBESAT & MENZ SAT in space, IPASS in Military, TIGERCENCE in Wireless Sensors Networks.

HODET

KINECT-KII

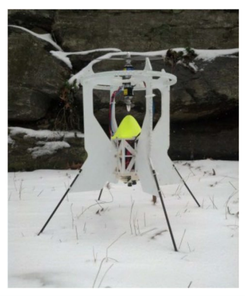


CUBESAT

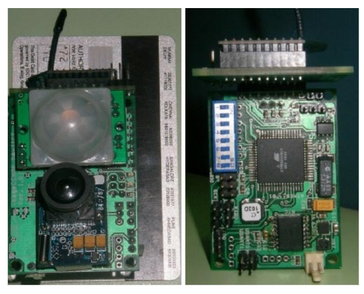


MENZ SAT

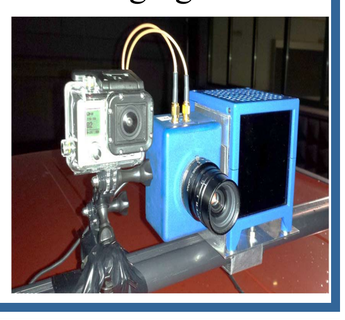
IPASS



TIGERCENCE

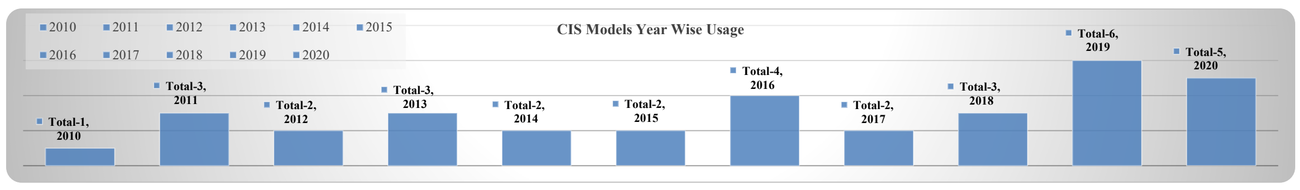


3D Ranging Camera



## Field wise mapping of CMOS image sensor model with Design characteristics

| S.No | Year | Technology | Camera Module | Resolution | SNR (dB) | Frame Rate (fps) | Dynamic Range (dB) | Application Name/Target | Field |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2009 | 0.35 µm | N/A | 64*64 | N/A | 10 | N/A | Built in lane Detection | Automotive |
| 2 | 2011 | 0.18 µm | N/A | 128*256 | 51 | 60 | 98 | Night Vision Systems | Automotive |
| 3 | 2012 | N/A | MT9 V125 | 720*480 | 39 | 30 | 70 | Fish-Eye Automotive Camera | Automotive |
| 4 | 2013 | 0.18 µm | N/A | 642*480 | N/A | 30 | N/A | Optical Wireless Communication System | Automotive |
| 5 | 2013 | 0.13 µm | N/A | 768*576 | 45 | N/A | 70 | On-Screen-Display (OSD) | Automotive |
| 6 | 2014 | 0.18 µm | N/A | 642*480 | N/A | 60 | N/A | Visible Light Communication | Automotive |
| 7 | 2015 | N/A | GUPPY-F036 C | 752*480 | N/A | 64 | N/A | Traffic light Detection | Automotive |
| 8 | 2015 | 0.35 µm | N/A | 64*32 | N/A | 100 | 110 | Three Dimensional Vision | Automotive |
| 9 | 2018 | 0.11 µm | N/A | 1280*1024 | N/A | 30 | N/A | Non Contact Heart rate Detection | Automotive |
| 10 | 2018 | N/A | OV7725 | 640*480 | 50 | 60 | 60 | Intelligent Car Path Tracking | Automotive |
| 11 | 2011 | N/A | OV6620 | 356*292 | >48 | 60 | >72 | Nilaparvata Lugens Monitoring System | IoT |
| 12 | 2011 | N/A | OV7640 | 640*480 | 46 | 30 | 62 | Crop Monitoring System | IoT |
| 13 | 2011 | N/A | Hercules Webcam | 1280*960 | N/A | 30 | N/A | Vine Yard Monitoring | IoT |
| 14 | 2013 | N/A | VBM40 | 1280*960 | N/A | 30 | N/A | Human Monitoring System in Sea Transportation | IoT |
| 15 | 2013 | N/A | OV9655 | 1280*1024 | N/A | 15 | N/A | Smart Camera Networks(SCN) | IoT |
| 16 | 2016 | 0.18 µm | N/A | 64*64 | N/A | N/A | 96.7 | Smart Image Sensor with Multi Point Tracking(MPT) | IoT |
| 17 | 2017 | N/A | N/A | N/A | N/A | N/A | N/A | Early Flood Detection & Control Monitoring | IoT |
| 18 | 2018 | N/A | OV7670 | 640*480 | 40 | 30 | 52 | Precision Agriculture System Design | IoT |
| 19 | 2019 | N/A | OV2640 | 1600*1200 | 40 | 15 | 50 | SMART HOME | IoT |
| 20 | 2019 | N/A | SF3324-101 | 1928*1208 | N/A | N/A | N/A | CUbE | IoT |
| 21 | 2009 | N/A | Quickcam Pro 9000 | 1600*1200 | N/A | 30 | N/A | Privacy preserving sensor for Person Detection | ISS |
| 22 | 2010 | 0.18 µm | N/A | 64*64 | N/A | 30 | N/A | surveillance in low crowded environments | ISS |
| 23 | 2015 | N/A | ucam-II | 128*128 | 44.2 | N/A | 51 | Visual surveillance and intrusion detection | ISS |
| 24 | 2017 | 0.18 µm | N/A | 176*144 | 47 | 14 | 61.8 | Multi Resolution Mode | ISS |
| 25 | 2018 | 0.09 µm | N/A | 2560*1536 | N/A | 60 | 67 | Moving Object Detection With Pre-defined Areas | ISS |
| 26 | 2019 | N/A | ZTE Nubia UINX511 J | 5344*3000 | N/A | 120 | N/A | Classroom Emotion with Cloud-Based Facial Recognizer | ISS |
| 27 | 2019 | N/A | DJI PHANTOM 3 PRO | 4000*3000 | N/A | N/A | N/A | vehicle Stacking Estimation | ISS |
| 28 | 2020 | N/A | OV2710-1 E | 1920*1080 | 40 | 30 | 69 | Nuclear Radiation Detection | ISS |
| 29 | 2020 | N/A | GS3-U3-23 S6 C-C | 1920*1200 | N/A | 162 | N/A | Contact less Neonatal Pulse Rate Sensing | ISS |
| 30 | 2020 | N/A | OV9653 | 1300*1028 | 40 | 15 to 120 | 62 | HODET | ISS |
| 31 | 2012 | 0.18 µm | N/A | 368*368 | N/A | 10 | 49.2 | Autonomous Micro Digital Sun Sensor | Space |
| 32 | 2013 | 0.35 µm | N/A | 256*256 | N/A | N/A | N/A | Lightning Detection and Imaging | Space |
| 33 | 2013 | 0.18 µm | N/A | 320*128 | N/A | N/A | 126 | STAR Tracking | Space |
| 34 | 2016 | N/A | CMV20000 | 5120*3840 | 41.8 | 0.45 | 66 | MARS 2020 Mission: EECAM | Space |
| 35 | 2017 | N/A | MT9 M001 C12 STM | 1280*1024 | 45 | 30 | 68.2 | Cube SAT Remote Sensing Imagers | Space |
| 36 | 2018 | N/A | CMV4000 | 2048*2048 | N/A | 180 | 60 | Cloud Monitoring Camera(CMC) System for Imaging Satellites | Space |
| 37 | 2019 | 0.11 µm | N/A | 3000*3000 | 45 | N/A | 72.4 | Radiation Tolerant Sensor | Space |
| 38 | 2019 | N/A | IMX 264 | 2464*2056 | N/A | 60 | N/A | Nanospacecraft Asteroid Flybys | Space |
| 39 | 2019 | N/A | OV9630 | 1280*1024 | 54 | 15 | 60 | Mezn Sat for monitoring Green House Gases | Space |
| 40 | 2020 | N/A | CIS2521 F | 2560*2160 | N/A | 100 | >86 | ASTERIA- A Space Telescope | Space |
| 41 | 2010 | N/A | OV9653 | 1300*1028 | 40 | 30 | 62 | Wireless Aerial Image System | Millitary |
| 42 | 2013 | N/A | OV7725 | 640*480 | 50 | 60 | 60 | IPASS | Millitary |
| 43 | 2014 | N/A | N/A | 640*512 | N/A | N/A | N/A | Banpil Camera | Millitary |
| 44 | 2016 | N/A | MPT 50 | 640*512 | N/A | N/A | N/A | MWIR Detector for MissileApplications | Millitary |
| 45 | 2016 | N/A | PHOTRON SA4 | 1024*1024 | 80 | 3600 | N/A | IN-SITU High velocity Rifle Bullets | Millitary |
| 46 | 2016 | N/A | OV7670 | 640*480 | 46 | 15 | 52 | Wireless Vision sensor | Millitary |
| 47 | 2017 | N/A | Flea3 | 4000*3000 | N/A | 15 | 66.46 | CARMA | Millitary |
| 48 | 2018 | N/A | ESN-0510 | 640*480 | N/A | 30 | N/A | Sticky Bomb Detection | Millitary |
| 49 | 2019 | 0.18 µm | N/A | 64*64 | N/A | 200 k | N/A | Gun Muzzle Flash Detection System | Millitary |
| 50 | 2020 | N/A | MC1362 | 1280*1024 | N/A | 200 hz | 90 | Critical Part Detection of Reconnaissance Balloon | Millitary |
| 51 | 2010 | N/A | C328 R | 640*480 | N/A | N/A | N/A | Tigercense | WSN |
| 52 | 2011 | 0.18 µm | N/A | 64*64 | N/A | 100 | N/A | On Chip Moving object Detection & Localization | WSN |
| 53 | 2011 | N/A | MT9 D131 | 1600*1200 | 42.3 | 15 | 71 | MasliNET | WSN |
| 54 | 2012 | 0.6 µm | N/A | 384*288 | N/A | N/A | N/A | Eco-Hydrological Monitoring | WSN |
| 55 | 2012 | N/A | C328-7640 | 640*480 | 46 | 30 | 62 | Monitoring Pest Insect Traps | WSN |
| 56 | 2013 | N/A | MT9 M001 | 1280*1024 | >45 | 30 | >62 | River Surface Target Enhancement | WSN |
| 57 | 2014 | N/A | OV5642 | 2592*1944 | 50 | 15 | 40 | TrustEYE.M4 | WSN |
| 58 | 2014 | N/A | OV7725 | 640*480 | 50 | 60 | 60 | Wild life Inventory | WSN |
| 59 | 2019 | N/A | IMX178 LLJ-C | 3088*2064 | N/A | 60 | N/A | Monitoring light pollution from small UAVs | WSN |
| 60 | 2019 | N/A | ELP-USBFHD04 H-L170 | 1920*1080 | 39 | 30 | 72.4 | SoilCam | WSN |




Year wise usage of CIS models involved in demanding fields, where x-axis represents years and y-axis represents number of CIS models.

## Conclusion

Charge-coupled devices (CCD) played a vital role in many applications until the CMOS image sensors came into existence. However, CIS still has some shortcomings to replacing CCDs in essential fields like the medical field and space, etc. To overcome CISs' shortcoming, s various technological advancements have been introduced during the last decade and have made CIS a leading good competitor to CCD in the present market. CIS is highly in demand in all reputed cameras and high spectral imaging applications due to its low manufacturing cost and size.

## References

[1]. Sukhavasi, S.B.; Sukhavasi, S.B.; Elleithy, K.; Abuzneid, S.; Elleithy, A. CMOS Image Sensors in Surveillance System Applications. Sensors 2021, 21, 488.