



**WINTECHCON 2018**

**September 28, 2018**

**Occupancy and People Detection on an  
Edge Device for Smart Building Automation**

**Raka Singh & Linet Paul**

**AEG Team- Analog Devices**



# Problem Statement

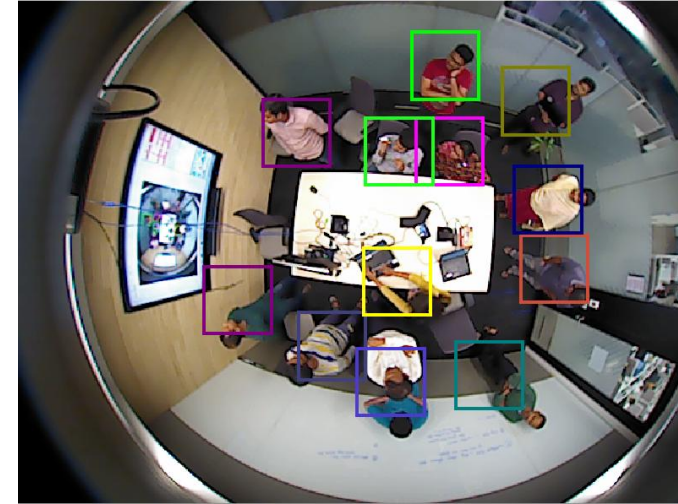
- a) *Automation of buildings for energy efficiency, space utilization and increase productivity of workplaces through measurement and control of several parameters such as temperature, oxygen flow, HVAC control is becoming important. Hence people counting and occupancy detection is an important sensing parameter.*
- b) *Efficient space utilization can optimize costs of estate management*
- c) *Improving the energy efficiency of building can result in gains in worker productivity in addition to energy cost saving.*
- d) *Occupancy detection and people counting on a edge device which can monitor a space, can enable automation of buildings and hence drive all these business use cases*
- e) *These application use cases require a solution which shall be on edge node. This is significant to protect the privacy, security, and have low latency. Also, there will be a data bandwidth limitation when hundreds of such sensors start sending images to cloud.*
- f) *The solution should support installation with ease, detection of people count and location accurately and be an end-to-end solution*

# Solution Approach

- a) *Our solution is an edge sensor that Counts people and detects occupancy, both accurately in closed or open spaces on a low powered edge device with a vision There are no other existing solutions which does this on a low powered edge device*
- b) *Analytics Algorithm which runs on a 400MHz low powered ADSP-BF707*
- c) *The algorithm uses innovative computer vision blocks in preprocessing, motion tracking, feature tracking, machine learning classifiers to accurately detect people and low motion and occupancy on a VGA resolution vision image*
- d) *Has a 3m - 5m radius coverage with a ceiling mounted single vision sensor*
- e) *Accuracy is 90%+ in most live scenarios ranging in complexity in real environments. The TP percentage in normal scenarios reaching 95%+ in many cases.*
- f) *Complete solution from sensor to cloud to enable business analytics on the cloud, based on the metadata such as occupancy status, people count being send from the edge node.*
- g) *Ease of use with OTA upgrade, Telemetry, Diagnostics, Mobile App based commissioning, WiFi to cloud.*

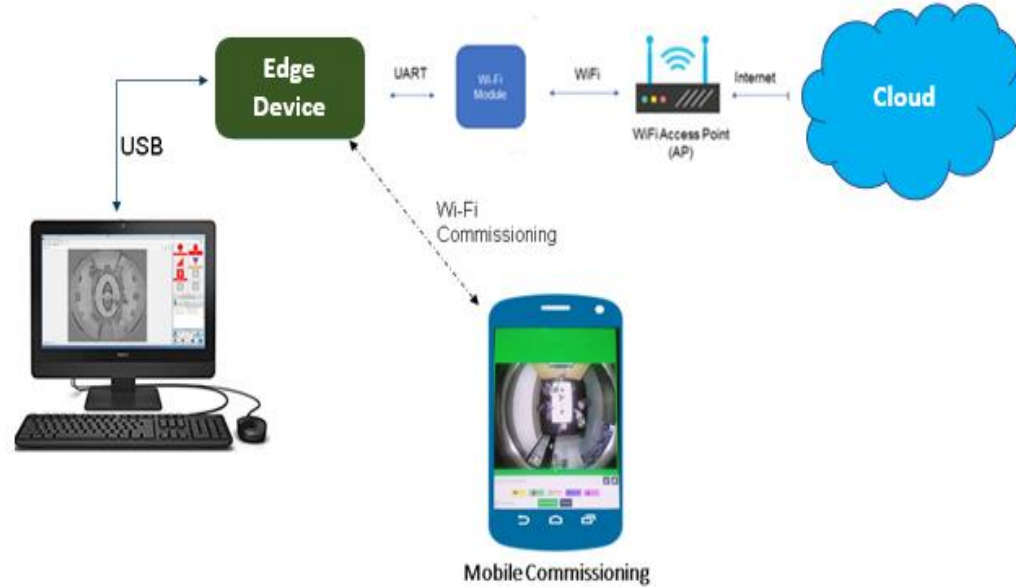
# Solution Approach

*Device Installation:*



# Solution Approach

## System Overview



# Experimental Results

| Benchmark Video                                                                 | True Positive (TP) % | Score %<br>TP/(TP+FP+FN) | Instantaneous Absolute Accuracy % |
|---------------------------------------------------------------------------------|----------------------|--------------------------|-----------------------------------|
| 58 video tests of different complexity, with 2-10 people, on 3m-4m radius rooms | 94                   | 88                       | 91                                |

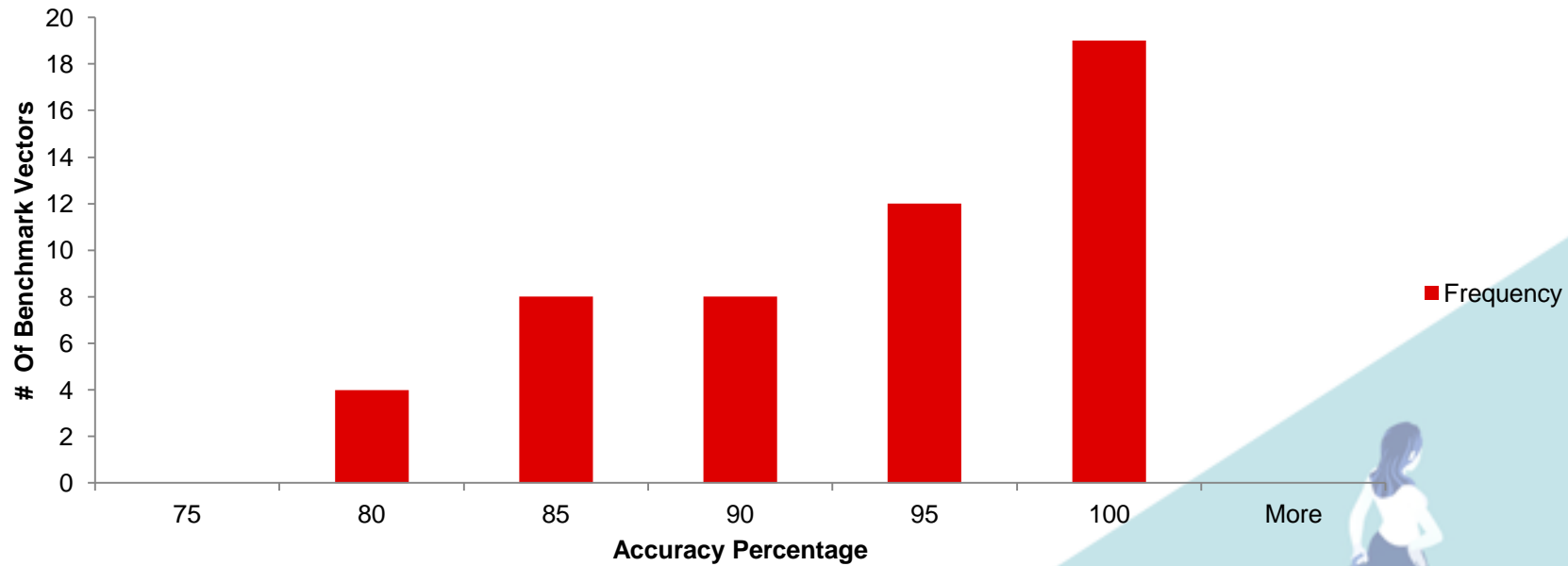
| Benchmark Video                                                                 | Average performance for one image (in msec) | Peak performance for one image (in msec) |
|---------------------------------------------------------------------------------|---------------------------------------------|------------------------------------------|
| 58 video tests of different complexity, with 2-10 people, on 3m-4m radius rooms | 54 (uses 54% of the 400 MHz processor )     | 62                                       |



# Experimental Results

- Count accuracy
  - Average 91% on 51 vectors of *normal conditions*\* in conference room of size 3m.

## Benchmark Accuracy Distribution



\* *Normal conditions* :Lux above 20, diffused lights, people at 1feet away from each other, people making some activity

# Experimental Results

The screenshot displays the 'RoomCount Sensor Demo' software interface. The main window shows a fisheye camera view of a meeting room with several people seated around a table. The interface includes a menu bar with 'Image source', 'View', 'Event logger', and 'Analytics Status'. Below the menu bar are tabs for 'Image', 'I/O Data', and 'Parameters'. A toolbar shows 'Fit' and zoom controls. The right-hand control panel contains several status indicators and settings:

- Light control: On (70%, 7 pers)
- Light level indicators: [1] 1824 Lx, [2] 2350 Lx, [3] 1125 Lx, [4] 1010 Lx
- Buttons: Light control (Auto), PIR Test Mode (not running), Reset Analytics, Reset Device
- Motion and Presence settings: Occupancy count, Trac, Visible motion, Presence entities, Light state sound, Room state sound
- RoomCount(USB0) controls: Disconnect, Rewind, Jump, Step, Pause
- Frame: 2304, 12:26:31.2, Capture: 1535
- Buttons: BoardCtrl, Config, SmartCam, Sensor
- Status: Not recording



# Experimental Results

The screenshot displays the 'RoomCount Sensor Demo' software interface. The main window shows a fisheye camera view of a meeting room with several people seated around a table. Each person is enclosed in a colored bounding box (purple, blue, green, red, cyan). The interface includes a top menu bar with 'Image source', 'View', 'Event logger', and 'Analytics Status'. Below the menu are tabs for 'Image', 'I/O Data', and 'Parameters'. A 'Fit' control is set to '1:1'. On the right side, there is a control panel with various indicators and buttons:

- Light Status:** A red lightbulb icon with 'On' text.
- Occupancy:** A red bar chart icon with '70%' and '7 pers' text.
- Light Levels:** Four lightbulb icons with numerical values: [1] 1706 Lx, [2] 2407 Lx, [3] 807 Lx, and [4] 1152 Lx.
- Control Buttons:** 'Light control (Auto)', 'PIR Test Mode (not running)', 'Reset Analytics', and 'Reset Device'.
- Motion and Presence Settings:** A section with checkboxes for 'Visible motion', 'Presence entities', 'Light state sound', and 'Room state sound'. 'Light state sound' and 'Room state sound' are checked.
- Playback Controls:** A section with 'Disconnect', 'Rewind', 'Jump', 'Stop', and 'Pause' buttons.
- Metadata:** 'Frame: 3153', '12:27:52.5', and 'Capture: 1852'.
- Device Status:** 'RoomCount[USB0]', 'BankIdr', 'Config', 'SmartCam', 'Sensor', and 'Not recording'.

The bottom left corner of the window shows the coordinates '(605, 363)'.

# Experimental Results

*When room is occupied with 12 people*

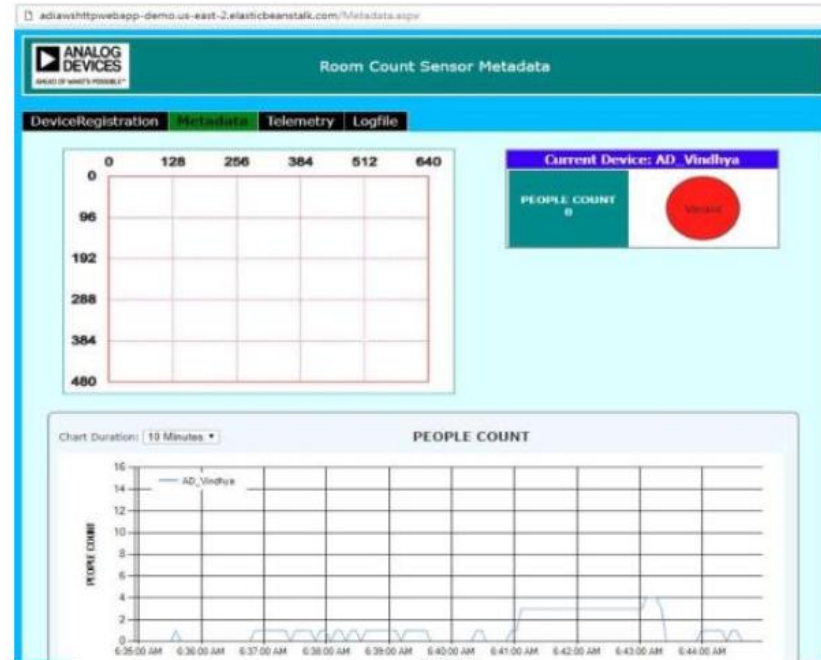
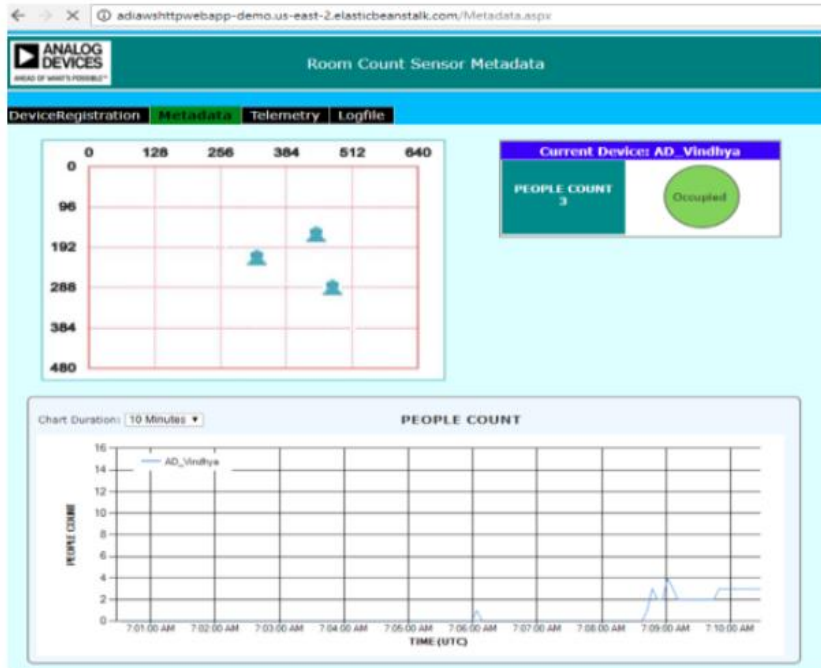
The screenshot displays the 'RoomCount Sensor Demo' software interface. The main window shows a 360-degree fisheye camera view of a room with 12 people. Each person is enclosed in a colored bounding box (green, yellow, purple, blue, red, orange, cyan, magenta, brown, grey, black, and white). The control panel on the right includes the following elements:

- Status:** On (red indicator), 100% occupancy, 12 pers.
- Light Control:** Four individual light level indicators: [1] 496 Lx, [2] 532 Lx, [3] 430 Lx, [4] 376 Lx.
- Control Buttons:** Light control (Auto), PIR Test Mode (not running), Reset Analytics, Reset Device.
- Motion and Presence:** Occupancy count, Trac (dropdown), Visible motion (checkbox), Presence entities (checkbox), Light state sound (checkbox), Room state sound (checkbox).
- Playback:** RoomCount[USB0], Stop, Play, Pause, Frame: 7802, 15:23:49.6, Capture: 246.
- Hardware:** Board, Config, SmartCam, Sensor.
- Recording:** Not recording (blue progress bar).

Coordinates (430, 150) are shown in the bottom left corner of the video frame.

# Experimental Results

## Data Display on Cloud



# Conclusions

- a) *Power – Complex Computer Vision algorithms run on a low power 400 MHz ADSP-BF707 Blackfin processor, which uses 500mA current.*
- b) *Cost – Cost/sqm is very less since one such edge device can monitor up to 30 sqm.*
- c) *Efficiency – Accuracy of people detection is 90%+ in real environment running for multiple days in different conference rooms. Occupancy detection is 95%+ in different lighting conditions*
- d) *Latency – Low latency metadata updates from Sensor to Cloud, ranging from 500ms to 5s*
- e) *Use of Ease - Cloud Application with business analytics derived from metadata. Device can be reset from cloud, upgraded over the air, Mobile App based configuration and commissioning.*
- f) *Security & Privacy – The analytics being run on the edge device ensures that image data never leave the sensor, hence protecting privacy. Our solution also provides security in terms of access to the device. The only data send is metadata such as people count and locations, occupancy*



# References

- Sunil Kumar Ghai, Lakshmi V Thanayankizil et al [Occupancy Detection in commercial building using opportunistic context sources](#), IEEE Conference on Pervasive Computing and Communication Workshops, May 2012
- Mykhaylo Andriluka, Stefan Roth, Bernt Schiele [People tracking by detection and people detection by tracking](#), IEEE Conference on Pattern Recognition and Computer Vision, 2008
- Gangqiang Shi, Weiwei Hu [The video people detection based on Neural Networks](#), IEEE Conference on Communication Technology, Oct 2015
- Bin Li, Jian Jhang, Zheng Zhang [A people counting method based on head detection and tracking](#), International Conference on Smart Computing (SMARTCOMP), 2014

