Automatic Passenger Counting with expandable features

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Director Business Development APC
History of APC technologies
Current status of systems
Future/trends of APC technologies
How it benefits transit agencies
Challenges
Accuracy issues
Reliability
Hardware maintenance issues
Etc.
Automatic Passenger Counting

- Detailed counts at stop level for every route
- Calculating on-time performance
- Ridership by trip, route, stop, time-periods, peak time etc
- NTD reporting
Agency expectation of an APC system?

- Most important: Accurate data
- Specify the margin of error it must meet
- Testing methods process of installed product
Automatic Passenger Counting

History of APC technologies

- Counting mats
- Side Beam Barrier
- Weight measurement (train)
- Reflection light scanner (active only)
- Thermo scanner (passive only)
- Combination of active and passive sensor
- Time of flight technology IRMA 3D
- Video based system
- **Time of Flight (TOF) technology produces 3D images**
## Current status of APC systems

<table>
<thead>
<tr>
<th>Counting Mats</th>
<th>Obsolete</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Beam barrier</td>
<td>Obsolete, but still in use</td>
<td>UTA, Trapeze (Red pine),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clever Devices</td>
</tr>
<tr>
<td>Active sensor tech.</td>
<td>Current</td>
<td>Dilax, Infodev, UTA,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IRIS IRMA Basic /INIT</td>
</tr>
<tr>
<td>Active Passive Tech.</td>
<td>Will be phased out in 2016</td>
<td>IRIS IRMA advanced /INIT</td>
</tr>
<tr>
<td>Time of Flight 4</td>
<td>Current</td>
<td>IRIS IRMA 3D /INIT</td>
</tr>
<tr>
<td>pixel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stereoscopic camera</td>
<td>Current</td>
<td>Hella</td>
</tr>
<tr>
<td>Time of flight 3D</td>
<td>Current</td>
<td>Iris IRMA Matrix /INIT</td>
</tr>
<tr>
<td>Images 500 pixel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Legacy Sensors

- **Horizontal Beams**

  Poor accuracy when there is a wide door on the bus and two people walk in at the same time

- **Low accuracy when bulk entries occur**

  What happens if somebody stands in the door way while another person walks out?
Example installation

- Video camera needs sufficient distance to object. Camera cannot be mounted in the door area. Needs height clearance.
- Dependent on sufficient light.
- Vulnerable to changing conditions (temperature, moisture, reflections).
- Active sensor: Low accuracy when bulk entries occur.
- Sensors have to be correctly adjusted to avoid false counts (maintenance costs).
APC Key Components

- Counting and analyzing
  - IRMA System

- Storing and Transmitting
  - OnBoard Computer

- Processing & Evaluating
  - MOBILEdvm
  - MOBILEstatistics
APC system integration

- Vehicle survey: Width and height of the door
- Mounting Location of Equipment
- Installation testing and verification
- APC Test Ride
- APC verification based on IRIS specification related to VDV Standard 457
Sensor Product Family

IRMA4-Basic
Active Infrared Signal Detection

IRMA4-Advanced
Active-Passive Infrared Signal Detection

IRMA4-3D
Infrared Distance Detection

IRMA5-Matrix
Infrared Image Detection
# Accuracy Overview

<table>
<thead>
<tr>
<th></th>
<th>IRMA Basic (Active)</th>
<th>IRMA Advanced (active/passive)</th>
<th>IRMA 3D TOFL</th>
<th>IRMA Matrix TOFL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger error</td>
<td>5%</td>
<td>5%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Balanced error for boarding passengers</td>
<td>13%</td>
<td>10%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Balanced error for alighting passengers</td>
<td>13%</td>
<td>10%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Typical Unbalanced error</td>
<td>NA</td>
<td>NA</td>
<td>10%</td>
<td>&lt; 8%</td>
</tr>
<tr>
<td>Required Passengers</td>
<td>1000</td>
<td>700</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
Accuracy IRIS Accuracy Definition

<table>
<thead>
<tr>
<th>Stops</th>
<th>Manual counting</th>
<th>IRMA counting</th>
<th>Error (absolute value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
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<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>50</td>
<td>48</td>
</tr>
</tbody>
</table>

In this example:

- The passenger error is \(\frac{(48 + 54) - (50 + 50)}{50 + 50} \times 100\% = 2\%\).
- The balanced entering passenger error is \(\frac{48 - 50}{50} \times 100\% = -0.4\%\).
- The balanced exiting passenger error is \(\frac{54 - 50}{50} \times 100\% = 8\%\).
- The unbalanced error is \(\frac{4 + 6}{50 + 50} \times 100\% = 10\%\).
**Accuracy IRMA Testride MTS San Diego**

### Statistical Evaluation

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>03000001.uff</td>
<td>6</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>+1</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
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<tr>
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<td>1</td>
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<td>1</td>
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<td>0</td>
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<td>0</td>
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</tr>
<tr>
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<td>0</td>
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<tr>
<td>9</td>
<td>0300009.uff</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>10</td>
<td>0300010.uff</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Sums:**

| 36 | 27 | 35 | 27 | +1 | 0 | 1 | 0 |

**Error Table:**

<table>
<thead>
<tr>
<th>Error</th>
<th>Boarding</th>
<th>Alighting</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balanced</td>
<td>2.9 %</td>
<td>0.0 %</td>
<td>1.6 %</td>
</tr>
</tbody>
</table>

**Passenger error:** 1.6 %

**Statistical base:** 62 passengers

- 25 door operations
- 24 error-free
Accuracy Overview MTS San Diego

Passenger error: 1.6%
Statistical base: 62 passengers
25 door operations
24 error-free

\[
\frac{(36 + 27) - (35 + 27)}{35 + 27} \times 100\% = 1.6\%
\]

\[
\frac{36 - 35}{35} \times 100\% = 2.85\%
\]

\[
\frac{26 - 26}{26} \times 100\% = 0\%
\]
Trends of technology

- Manual Sensor Calibration towards easy maintenance free installation
- Fulfillment of higher Accuracy Requirements needs smarter technology Counting for Wheelchair, bikes, stroller.
Automatic Passenger Counting

- Active Infrared Receiver
- Passive Infrared Sensor
- Mounting Screws
- Adjusting Screws
- Active Infrared Transmitter
Automatic Passenger Counting

[Image of a graph showing signal graphics with time and voltage data, labeled with various elements and cycles.]
Automatic Passenger Counting

[Image of a train carriage floor with markings for Outer and Inner Curtains]
Sensor Overview

- Laser light pulse is emitted and reflected by an object and picked up again by the sensor. The distance results from the runtime between time of emission and time of reception (Time of Flight).

- Sensor signals are independent of environmental influences and changes:
  - Temperature
  - Luminance
  - Humidity
  - Reflective and non-reflective surfaces

- Analyser processes the sensor signals and calculates the passenger count

- No adjustment of the sensor needed.

- Maintenance free and vandal resistant
Detection Signals Using IRMA 3D Sensor

Door centre

Outside

Vehicle Inside
IRMA 3D testride in DRT Durham

Iris performed the accuracy test ride two weeks ago
Higher Accuracy Requirements

An APC system with the following additional features shall be proposed:

The APC shall have the ability to recognize and classify regular passenger objects such as wheelchairs, stroller, bicycles, etc. with a 95% accuracy.
Sensor features:

- 500 detection pixels / image data per sensor ("matrix sensor")
- The sensor "sees" the door area, i.e., works like camera

Results

- Easy adjustment to door condition, **no calibration**
- Door contact cables no longer required
- Precise counting due to higher quality of signal information
- Count accuracy 98+% without on-board data manipulation
- Integration of the analyzer features into sensor (possible due to small subcomponents), i.e., sensor connection directly to on-board system
- Simple software integration via Advanced Programming Interface (API). The API provides all sensor functions and messages.
The speed of light converts the time of flight into distance:

\[
\text{distance} = \frac{ct}{2}
\]
How does the technology work

Sensor

Passenger
IRMA Matrix Sensor Features

Surface mount version

- 500-pixel infrared sensor matrix
- Time of Flight technology (ToF)
- Real time capture of passenger loads
- Low installation effort - No adjustment work needed
- 1 sensor per standard door
- Distinction between Passengers and objects, also in bulk entries
- No door contact required - Sensor receives door release signal from On-Board-Unit for activation
- Ethernet interface 100 Mbit/s
- Can easily be integrated in existing systems
- Detection of height profiles - Distinction between adults and children for accurate revenue distribution

Flush mount version
Installation Overview

S-Con Connector

Flush-Mounted-Version

(Vandalism-proof)

External mount-Version

(Vandalism-proof)
Installation Overview

X = Y
IRMA Test Ride

Passenger error: 0.0 %
Statistical base: 78 passengers
21 door operations
YRT NOVA bus: 1 sensor per wide door
IRMA Test Ride

RTD Gillig bus: 1 sensor per wide door
IRMA Test Ride

WELCOME ABOARD
Outlook: Coming Soon

• Height classification

• Detection of wheel chairs, strollers, bicycles, ...

• Detection of vandalism (covering, damages)
Sensor Evolution Based on IRIS/INIT

- Passive IR
  - IRMA
  - 1990

- Passive IR + Active IR
  - IRMA ADVANCE

- Active IR
  - IRMA BASIC
  - 2000

- Time-of-Flight (TOF)
  - IRMA 3D

- 3D Vision via TOF
  - IRMA MATRIX
  - 2010
IRMA Matrix 3D vision based on TOFL

- 5th APC generation of iris: Latest **Time of Flight (TOF)** technology produces **3D images** instead of 2D contrasts of detection area, people and objects.

- Innovative TOF technology: evaluates **real distance and contour data** for most accurate people counting, detects individual people according contour and movement, distinguishes between people and objects.

- **High counting accuracy** independent of color, temperature, changing background, ambient light, reflections, ...
• 5th APC generation of iris: Latest **Time of Flight (TOF)** technology produces **3D images** instead of 2D contrasts of detection area, people and objects.

• Innovative TOF technology: evaluates **real distance and contour data** for most accurate people counting detects individual people according contour and movement, distinguishes between people and objects.

• **High counting accuracy** independent of color, temperature, changing background, ambient light, reflections, ...
Complete Reporting with MOBILEStatistics
Before the Burn-In must be a pre-test to check if all functions are existent.
The applicable test is to be performed over a length of time of 46h.
The quantitative end-test takes place after Burn-In.
Thank you for your attention

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