INTERNET OF THINGS –GROUP 4

PUBLIC TRANSPORTATION

OPTIMIZATIONPHASE 3

STUDENT NAME : SUVEDHA.C

REGISTER NUMBER :822621106013

COLLAGE NAME :ARIFA INSTITUTEOFTECHNOLOGY

COLLAGE CODE :8226

NM ID : au822621106013

EMAIL ID :suvedha2424@gmail.com

Nowadays, passenger counting operations are often developed onsurveys, throughout the territory and using manual procedures: eventhough these may be capable of providing highly accurate values, whichcan be taken as a reference point in analysing the precision of theautomatic systems, the manual procedures are not usually homogeneousin surveys, since they inevitably depend on the operator who performsthem and may also be influenced by the time of the day – early morningversus the last hours of the day – and by a repetitive task.

On the other hand, the APC (Automatic Passenger Counting)systems, can be much more appropriate and of greater interest, asrelated to this short analysis. It is important to underline that – eventhough most of them are still at a development stage – the passenger
counting technologies available on the market are various and the issues of different kinds; the combinations of technologies are such that nosolution can be considered to date better than others or economicallypreferable a priori; every solution should be analysed in detail forapplying it thereafter to the actual conditions of the public transportsystem or company.

This article is intended to shortly examine the different solutions ofpassenger counting technologies and to provide some suggestions asrelated to the management of data, in order to outline a generalframework which may facilitate a more justifiable, customised choice ofan automatic counting system.

Tools and technologies

In order to count people on buses, tramways, metros and trains, the twomain following procedures can be summarised:

1. Counting independently from the ticket (for buses, tramways,trains): a. monitoring of single passengers, usually by technologieson-board the vehicle; b. monitoring of the overall load on the

   vehicle, with technologies applied to the suspensions/air springs oron the ground

2. Counting related to the ticket (for metros, trains), sometimes also recognised as ERF (Electronic Registering Fareboxes) solutions.

In the former case, the counting can be based either on the detectionor attempted detection of the single passengers or indirectly, usually byascertaining the weight of the vehicle under the passenger compartmentor on the infrastructure, that is normally the road pavement.

As usual, the cost of the system needs to be contained, and this isrelated not only to the type of technology but also to the relevanthardware-software combination.

The ‘1a’ type solutions – frequently obtained by using a doublesensor – can be frequently more expensive than the ‘1b’ ones; this isessentially due to the need for developing appropriate counting stations:for instance, in a 12m, 3-door bus, six sensors and two dedicated
stations may be usually required.

Counting independently from the ticket has to be carried out bymeans of appropriate sensors, which may detect the passage of peoplethrough gates, usually the doors of buses, tramways and trains. Somemanufacturers of APC technologies supply equipment which canperform such function; a widespread solution is based upon the use ofinfrared sensors, which act as active switches; in case of passiveswitches, pyro electric sensors can be used.

In some of them, only infrared (IR) ray switches are used, in otherones, double sensors (e.g. active and pyro electric IR) are used toenhance the reliability of the counting.

As far as this topic is concerned, the manufacturers declare accuracyin passenger counting with an error contained between 5 and 10% on
the total amount of passengers which are actually present. However, theclass ‘1a’ counting systems are frequently still at experimentation stageand would be worth further investigation both as related to the CANintegration and in the assessment of the counting reliability.

In the ‘1b’ cases, counting can be developed indirectly, on the basisof the load on-board or by monitoring the weight directly by means ofplate sensors; a further alternative, analysed further on, is the detectionof the vehicle load on the ground.

In the former case, the number of people can be detected byassuming the average weight of a person: the counting is performed byload sensors either on the ground or on the suspensions: various typesare available and are nowadays experimented in other contexts as well.The main disadvantage linked to this kind of counting is the variabilityof the dynamic load on the shock absorbers, besides the lack ofimportant actual field experimentation documented in the literature.

infrared sensors

The infra-red detectors can be divided into two main categories, namely:
» Sensors of the active type, consisting of a transmitter and a receiver; they create a punctual ray and operate as on/off detection

» Sensors of the passive type, which divide the sole infra-red ray intobundles, thus creating an area of volumetric detection.

In the first case, the infra-red emitters are generally set parallel to oneanother so that the LED interruption occurs in the direction of crossingand the entry direction can thus be discriminated from the exit one:

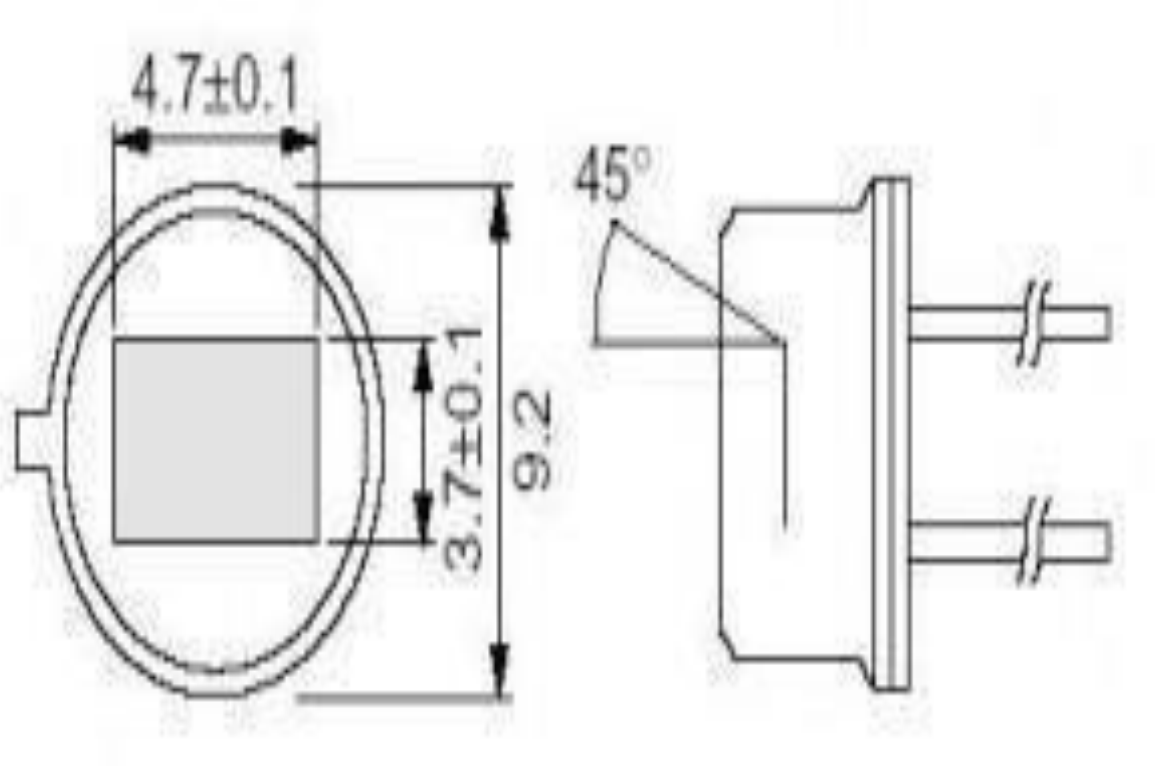
because of their ‘bar’ configuration, this type of infra-red sensor is also defined as ‘barrier sensors’

A weak point in this automatic counting solution – which, amongstother things, can also be easily found in commerce – is the need ofinstalling more than one sensor per door, with a consequent costincreasing. In order to prevent the infra-red ray from being avoided by apassenger and evaluate the crossing direction, a minimum amount of

two sensors is to be installed on every gate, but the number of LED’s may increase remarkably if the gates are larger than 2m.

The use of passive components generates a less punctual ray (theLED is replaced by emitters which generate ‘widened’ infra-redbundles), composed by two parallel arrays whose arrangement allowsdiversifying the two typologies of signal reflection, whether thepassengers are entering or leaving the vehicle.

The issues relevant to the number of sensors to be utilised and – subsequently – to their cost cannot be overlooked because, as in the caseof the active systems, more than one sensor per door is to be applied todetect the passage direction. As mentioned above, the electronic deviceused by the passive infrared-red sensors is pyro electric i.e. it ‘reacts’ tothe sudden temperature variations or – better – to the infra-red radiationemitted by a human body; this typically emits a frequency included in
the range between 7 and 14 μm.



Solutions with sole passive components are often utilised to detect themotion in surveillance systems of large-sized internal or externalenvironments; adapting them to automatic counting is not difficult, but
– if the coverage bundle emitted by the sensor is too large, the countermay be erroneous.

The application of passive infra-red sensors, conceived for the soledetection of people, and which can be modified with the support of acounting device, is often rather expensive. The market provides evensolutions that – in order to count the entries and exits with the greatestaccuracy – use a sensor which contains both a passive and an activecomponent.

Python Script for Interfacing IR Sensor with Raspberry Pi. IRProximity Sensor using Raspberry Pi.

```
import RPi.GPIO as GPIO
import time


sensor = 16   buzzer =
18
```

```
    GPIO.setmode(GPIO.BOARD)
    GPIO.setup(sensor,GPIO.IN)GP
    IO.setup(buzzer,GPIO.OUT)


  GPIO.output(buzzer,False)
  print "IR Sensor
  Ready....."print " "


  try: while True:
ifGPIO.input(sensor):GPIO.output(buz
zer,True) print"Object
Detected"
whileGPIO.input(sensor):
            time.sleep(0.2)
else:
          GPIO.output(buzzer,False)
```

except
KeyboardInterrupt:GPIO.clea
nup()

Treadle mat sensors

Treadle mats – placed on the steps of a bus, a tram or a train – register passengers as they step on a mat. This solution relevant to theAPC technologies is produced by several companies operating in thetransport industry: the counting system uses treadle mats located inproximity of the vehicle gates, typically on the access steps.

The metal structure can be covered by a layer of rubber and attachedto the steps by means of purposely-allocated attachment structures, orsimply glued by means of high seal adhesives; the latter solution is lessfrequently applied because it may deteriorate rather quickly.

Their installation generally does not call for special care; it mustnevertheless be considered that the edge of the mat is not active, i.e. itdoes not commute the switch; subsequently, the position of the mat is tobe studied and experimented so that the metal plate deforms every time
a person transits on it, in order not to obtain wrong data due to missingdetection.

if the public transport line equipped with this kind of APC is alwaysvery crowded, the errors can be relevant and – in such cases – the use ofdifferent means, such as passive IR sensors, may be preferable, or theaccess to the vehicle and exit from it can be managed by otherinstruments – such as turnstiles – to have a ‘Main components linked toan APC system and errors

The analyser is an essential component for the connection betweensensors and servers – be they on-board or remote – of an APC system: itdetermines the number of passengers in in-feed and out-feed on the
basis of the signals transmitted by the sensors.

As visible in, the analyser is connected to the following essentialfunctional units:

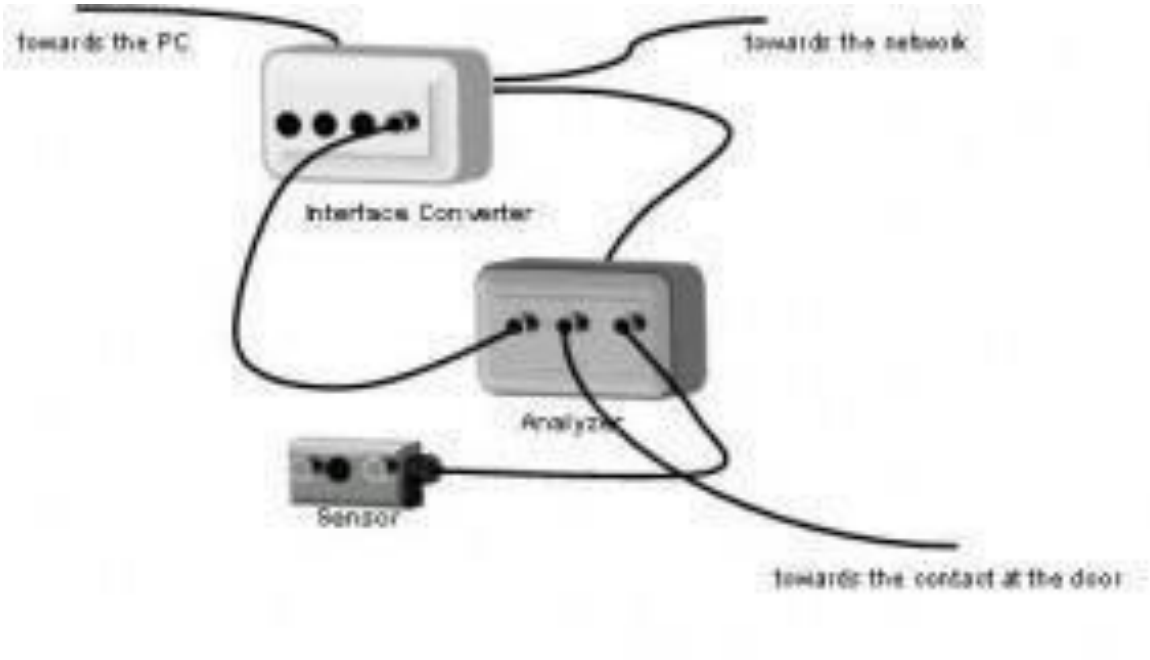
» Power supply (24V dc)

» Micro-control based signal processing

» Sensor interface

» Data bus interface2

» Modem for radio transmission of the data.



Last but not least, the significance of the appropriate electricalinsulation of the analyser, cables and all the components connected tothe APC system should not be overlooked, mainly in the case of passiveinfra-red systems, which are particularly sensitive to both theelectromagnetic sensors and the heat.

In general, the analysers have one, two or four connections per sensorand either one or two connections per door contact; subsequently, ananalyser can be connected to a maximum amount of two door sensors:this is an important factor to be evaluated when designing andprogramming the whole system. The transmission of data betweenanalyser and sensor is regulated by a microcontroller.

It is important to keep into account the errors in passenger counting; an objective judgement in passenger counting, should consider namely:

» The error on the total number of passengers

»The error on passengers in in-feed and out-feed

»The unbalance error.

The unbalance error describes the absolute errors and – therefore – itis particularly important in comparing the different installations and theAPC systems.

The field experience accrued in several years and many applicationsensures the following values for the rough data (i.e. the ones consideredbefore processing) of the passenger counting system:

» Passenger error ≤ 5%

» Passenger error in in-feed ≤ 10%

»Passenger error in out-feed ≤

10%.**serial read using the Python**

REPL

```
>>> import serial
>>> import time
>>> ser = serial.Serial('COM4',9600)
>>> time.sleep(2)
>>> b = ser.readline()
>>>
bb'409\r\
n'
>>> type(b)
```

<class 'bytes'>

```
>>> str_rn = b.decode()
>>> str_rn
'409\r\n'
>>> type(str)
<class 'str'>
>>> f = float(str)
>>> f 409.0
>>> type(f)
<class 'float'>
>>> ser.close()
>>> exit()
```

Main components linked to an APC system and errors

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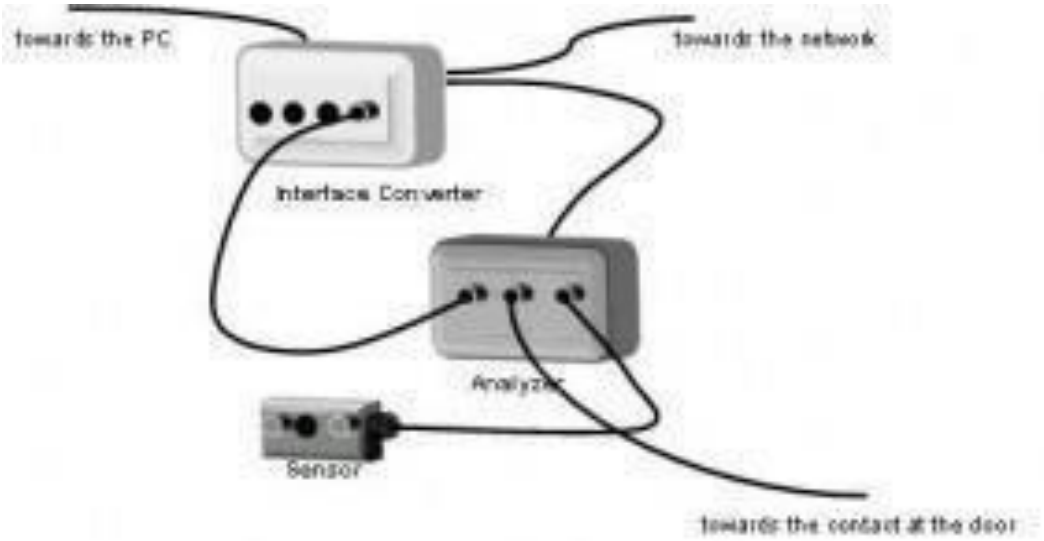

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