The Foretelling Subway: Environment and Situation

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ABSTRACT

In this work we introduce the environment for passenger occupancy prediction

1. INTRODUCTION

The remainder of this paper is organized as follows. In Section 2 an overview of Environment is given. Last, Section 3, draws our conclusion.

2. ENVIRONMENT

Underground transportation systems have significant impacts on energy consumption at a regional scale. While the transportation systems, i.e. trains, has observed regarding energy efficiency, the subsystems of metro stations and surroundings, such as ventilation, escalator and lightning are mostly unexplored.

Although a nominally small percentage of energy can be saved with an efficient management of these subsystems, a large energy saving in absolute terms can be obtained. In other words a 5% energy saving in non-traction electricity consumption in one year, is equivalent to the electricity consumed in more than 700 households.

2.1 SEAM4US project

To research in the area of energy efficient surroundings, the EU funded the "Sustainable Energy mAnageMent for Underground Stations" (SEAM4US) project in the Seventh Framework Programme. The aim of SEAM4US project "is to develop advanced technologies for optimal and scalable control of metro stations [...]. The project's main outcomes will be the creation of systems for optimized integrated energy management, and the development of a decision support system to drive mid-term investments" [1]. The integrated energy management is realized by employing passenger density models and thermal models, integrating sensors and control algorithms in a model predictive control architecture [2]. The control architecture proactively controls the metro station surroundings (ventilation, escalator, and lightning) under different occupancy and thermal conditions.

The SEAM4US consortium consists of nine partners from six different EU countries, namely Cofely, UniVPM, UPC, Fraunhofer FIT, VTT, Almende, University of Kassel, CNET and TMB.

Cofely is a major player in energy-efficient system management sector. UniVPM and UPC are experts in building and environmental physics and construction. Fraunhofer FIT and VTT support the consortium as R+D experts in middleware. Almende and UniKassel research in area of user and agent-based scheduling modeling and CNet supports as system integrator. The large metro network operator Transports Metropolitans de Barcelona (TMB) supports with its experience with underground systems as well as the model underground station. A overview over the SEAM4US consortium is given in Table 1.

Name	Country
Cofely Italia Spa	Italy
Universita Politecnica Delle Marche	Italy
Universitat Politecnica De Catalunya	Spain
Fraunhofer-Gesellschaft Zur Foerderung Der Angewandten Forschung E.V	Germany
Teknologian Tutkimuskeskus VTT	Finland
Universitaet Kassel	Germany
Almende B.V.	Netherlands
CNet Svenska AB	Sweden
Ferrocarril Metropolita De Barcelona Sa	Spain

Table 1: SEAM4US consortium

2.2 Metro Station "Passeig de Gràcia"

The implementation of the developed technologies is done in one of the stations of the partner TMB in Barcelona. To validate the system, it is installed in a underground station in Barcelona. This section describes the "station" in detail, while the word "station" in the area of metro networks needs to be defined first.

Starting high level, a metro network is composed by one or more metro lines. Each line has a fixed railway with a given number of stops to allow people to get on or off the trains by means of a platform: each of these stops is called "line station". A "metro station" is the concept that represents the point in space through which a passenger gets underground and into a line station. Metro station and line station can be the same physical entity, but it is possible that there are some "metro stations" that receive two or more "metro lines" in different platforms, and have therefore, two or more "line stations" within.

The data, used in this work, are gathered in line station in Passeig de Gràcia - Line 3 (PdG-L3) located in Barcelona. Passeig de Gràcia (PdG) is a station in the metro network of "Transports Metropolitans de Barcelona" (TMB) and lies in a very iconic and touristic part of Barcelona. Some of the popular buildings designed by Antoni Gaudí are in the proximity (Casa Batllò, Casa Milà), as well as the city's most renown and exclusive boutiques. The metro station is one of the oldest of the Barcelona metro network. First opened in December of 1924, as a (line) station for Line 3, nowadays PdG holds three different line stations: L2, L3, and L4. The stations were built in three different periods and using different construction technologies. All line stations has been refurbished a few times since 1924 and new equipment has been added recently.

Figure 1: PdG Entrance/Exit Gran Via. [3]

Depending on the weekday PdG is open 19 hours, 21 hours or 24 hours. Between Monday and Thursday PdG service starts at 5:00 and ends at 24:00 (19 hours). Friday service starts at 5:00 and ends at 2:00 (21 hours). On Saturday service starts at 5:00 to but remain the entire night until midnight on Sunday.

Passeig de Gràcia - Line 3 (PdG-L3) turns out to be representative for many station within TMBs metro network [?]. Moreover PdG-L3 is a crowded station which have low-rate usage hours as well. This provides a wide range of data which allows to test with very busy peak hours as well as with off-peaks.

The line station PdG-L3 consists of private (staff only) and public spaces. Private spaces such as technical rooms or staff dependencies are not part of the investigation. Public spaces, such as halls, transit areas, accesses to the platforms, and platforms are however in the focus on the SEAM4US project.

Essential part of underground line stations are the platforms, which allow passengers to leave and enter trains. PdG-L3 laid out on a PRRP (Platform-Rail-Rail-Platform) schema. The platforms in PdG-L3 are visible on Figure 2.

A schematic representation of PdG-L3 is drawn in Figure 3, where the accesses to platforms are highlighted in red.

Figure 2: PdG-L3 Plattforms. [3]

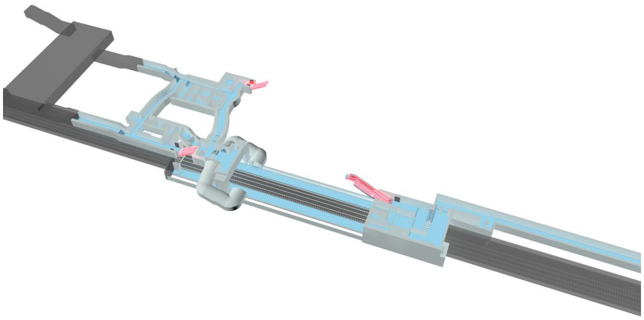

Figure 3: Schematic representation of PdG-L3. The accesses to platforms are highlighted in red. [?]

The passenger density models, as one part of the predictive controller, is based on existing CCTV cameras enhanced with image processing to detect current levels of passenger density. In the following section the CCTV system and the images processing is described briefly.

2.3 Passenger density level detection

Throughout the station a Closed Circuit Television (CCTV) surveillance system is installed. 20 CCTV cameras provides images initially for security reasons. Figure 4 show exemplary CCTV cameras in a transit area (Figure 4(a)) as well as on the platform (Figure 4(a)).

The CCTV system is reused in order to extract the passenger density within the station.

Whenever camera pictures are processed privacy issues are tackled. In order to ensure the passengers privacy several design constrained where defined:

1. All CCTV images are processed within the station.

2. The image processing is performed on a separate computer, which is not connected to other TMB Systems and is only accessible via a dedicated VPN connection.

(a) CCTV camera installed in a PdG transit area. [3]

(b) CCTV camera installed in PdG-L3 platform. [3]

Figure 4: Passenger density distribution of one CCTV camera in PdG-L3.

3. All CCTV images are processed "on the fly". For the purpose of level of passenger density extraction no CCTV image is saved.

4. The image processing works without human interaction.

5. The image data are filtered to avoid recognisability of individuals.

6. Processing results are transmitting only in terms of integer numbers to the database.

With respect to these design constrains the passenger density extraction was implemented. The work flow is described in the following.

First, the video streams coming from all cameras are combined into one single video stream by a video recorder. This video recorder creates a carousel video composed of sections for the individual camera appearing in a predefined order. The duration of the camera sections is set to 3 seconds. With 20 cameras and 3 seconds hold on each, one turn of the carousel is completed in about one minute.

The video recorder is connected to the local computer and transfer the images subsequently. On the local computer the density estimator processes the transferred images.

The density estimator extracts the passenger density on the image. The image process algorithm is described briefly in the following.

The density estimator algorithms use a combination of edge detection and background subtraction. In the following the algorithm is described briefly.

First the algorithm separates background and foreground. Followed by creating the foreground mask. Through filtering the edges of the foreground only are extracted. The foreground edges are combined with the foreground mask. Finally the result is refined by dilating (and then eroding) the segmented the blobs.

For different reasons, e.g. occluded or damaged camera, it is possible that the crowd density estimator fails. In this case the image processing return the error value "-1".

Finally the passenger density level as well as date, time and the camera-ID of the image are transmitted to the database. The general approach is depicted in Figure 5.

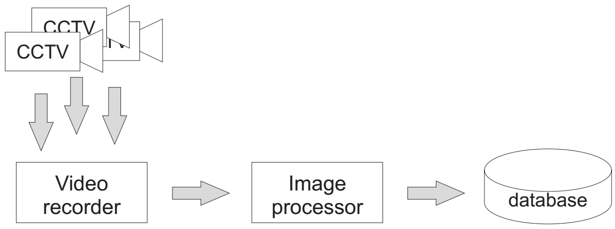

Figure 5: Gathering number of people out of the camera images.

The CCTV and image processing runs 24 hours, 7 days a week. Each day 28800 datasets are transmitted to the database. Overall the database contains 90 days of data.

2.4 Passenger density level

Figure 6(a) illustrates exemplary the available values of a camera and week. At a more detailed view Figure 6(b) shows the passenger density level of a camera and (week)day. On both Figures the PdG service times are visible due to the low passenger density level between 1am and 5am on weekdays.

3. CONCLUSION

Conclusion

Acknowledgements

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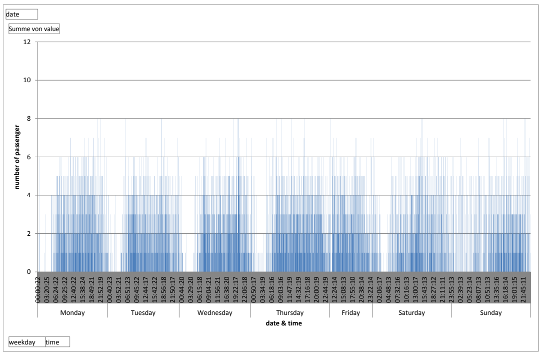
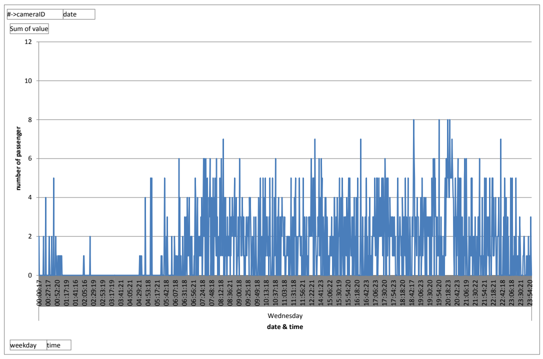
4. REFERENCES



(a) Passenger density distribution of one camera during one week.



(b) Passenger density distribution of one camera during one day.

Figure 6: Passenger density distribution of one CCTV camera in PdG-L3.

[1] Seam4us offical website. `http://seam4us.eu/`. Accessed: 2014-05-19.

[2] Roberta Ansuini, Massimo Vaccarini, Alberto Giretti, and Sara Ruffini. Models for the real-time control of subway stations. Chambéry, France, August 2013.

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