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Proceedings, Part II

Part II

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Preface

ACIIDS 2015 was the seventh event in the series of international scientific conferences for research and applications in the field of intelligent information and database systems. The aim of ACIIDS 2015 was to provide an internationally respected forum for scientific research in the technologies and applications of intelligent information and database systems. ACIIDS 2015 was co-organized by Bina Nusantara University, Indonesia and Wrocław University of Technology, Poland in cooperation with Ton Duc Thang University, Vietnam and Quang Binh University, Vietnam, and with IEEE Indonesia Section and IEEE SMC Technical Committee on Computational Collective Intelligence as patrons of the conference. It took place in Bali, Indonesia during March 23–25, 2015.

Conferences of series ACIIDS have been well established. The first two events, ACIIDS 2009 and ACIIDS 2010, took place in Dong Hoi City and Hue City in Vietnam, respectively. The third event, ACIIDS 2011, took place in Daegu, Korea, while the fourth event, ACIIDS 2012, took place in Kaohsiung, Taiwan. The fifth event, ACIIDS 2013, was held in Kuala Lumpur in Malaysia while the sixth event, ACIIDS 2014, was held in Bangkok in Thailand.

We received more than 300 papers from about 40 countries all over the world. Each paper was peer reviewed by at least two members of the International Program Committee and International Reviewer Board. Only 117 papers with the highest quality were selected for oral presentation and publication in the two volumes of the ACIIDS 2015 proceedings.

Papers included in the proceedings cover the following topics: semantic web, social networks and recommendation systems, text processing and information retrieval, intelligent database systems, intelligent information systems, decision support and control systems, machine learning and data mining, multiple model approach to machine learning, innovations in intelligent systems and applications, artificial intelligent techniques and their application in engineering and operational research, machine learning in biometrics and bioinformatics with applications, advanced data mining techniques and applications, collective intelligent systems for e-market trading, technology opportunity discovery and collaborative learning, intelligent information systems in security and defense, analysis of image, video and motion data in life sciences, augmented reality and 3D media, cloud-based solutions, Internet of things, big data, and cloud computing.

Accepted and presented papers highlight new trends and challenges of intelligent information and database systems. The presenters showed how new research could lead to new and innovative applications. We hope you will find these results useful and inspiring for your future research.

We would like to express our sincere thanks to the Honorary Chairs, Prof. Harjanto Prabowo (Rector of the Bina Nusantara University, Indonesia) and Prof. Tadeusz Więckowski (Rector of the Wrocław University of Technology, Poland) for their supports.

Our special thanks go to the Program Chairs, Special Session Chairs, Organizing Chairs, Publicity Chairs, and Local Organizing Committee for their work for the conference. We sincerely thank all members of the International Program Committee for their valuable efforts in the review process which helped us to guarantee the highest quality of the selected papers for the conference. We cordially thank the organizers and chairs of special sessions which essentially contributed to the success of the conference.

We also would like to express our thanks to the Keynote Speakers (Prof. Nikola Kasabov, Prof. Suphamit Chittayasothorn, Prof. Dosam Hwang, and Prof. Satryo Soemantri Brodjonegoro) for their interesting and informative talks of world-class standard.

We cordially thank our main sponsors, Bina Nusantara University (Indonesia), Wrocław University of Technology (Poland), Ton Duc Thang University (Vietnam) Quang Binh University (Vietnam), and patrons: IEEE Indonesia Section and IEEE SMC Technical Committee on Computational Collective Intelligence. Our special thanks are due also to Springer for publishing the proceedings, and to other sponsors for their kind supports.

We wish to thank the members of the Organizing Committee for their very substantial work and the members of the Local Organizing Committee for their excellent work.

We cordially thank all the authors for their valuable contributions and other participants of this conference. The conference would not have been possible without their supports.

Thanks are also due to many experts who contributed to making the event a success.

March 2015

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A System for Real-Time Passenger Monitoring System for Bus Rapid Transit System

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Abstract. TransJakarta is a BRT-based mass transportation system operating in Jakarta, the capital of Indonesia. Currently, the system delivers rather low level of service; as a result, the number of passengers is rather low in comparison to that of the other BRT-based systems. In this work, we propose a design of the passenger counting system for BRT-based system, which is very important for the BRT fleet management to increase the system level of service. The counting system is established by deploying computer vision techniques. A few algorithms are evaluated and the Adaptive Median Filtering with the sampling rate of 13 produces the highest level of precision and recall.

Keywords: Computer vision · Passenger counting system · Background substraction · Bus rapid system

1 Introduction

Traffic congestion is a major issue faced by many large cities across the globe. Jakarta, the capital of Republic of Indonesia, also deals with the problem in the daily basis. The congestion has caused the city setback in various sectors. In the economic sector, the predicted loss due the congestion is about Rp 65 trillion per year or about 5 billion USD. Within this number, about Rp 35 trillion per year or about 2.8 billion USD are due to the lost in the vehicle operation [1]. The congestion also has negative impacts in health, environment, and social sectors.

Metropolitan cities require structured mass transportation systems to lessen the level of congestion [2]. The system can be based on rail system or on bus system. The bus system is often called as the Bus Rapid Transit (BRT) system. The rail-based system has larger capacity, but requires longer development time and higher cost. In the other side, the BRT system has smaller capacity, but requires shorter development time and lower cost.

The adoption rate of the BRT system is higher than that of the rail-based system since the last decade. The adoption rates of the both systems are shown in Fig. 1.

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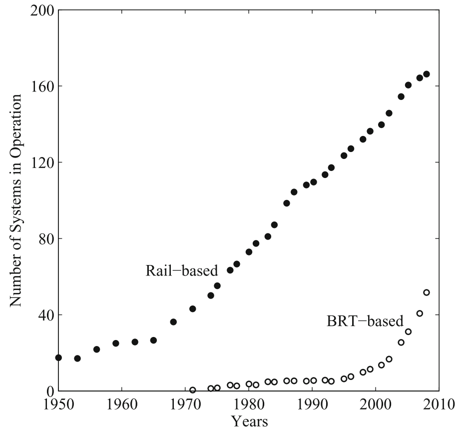

Fig. 1. The number of development of the train-based and BRT-based public transportation systems across the globe [3]

Jakarta also adopts the BRT system and was firstly constructed in 2004. The system is called TransJakarta BRT. By 2014, TransJakarta already has 12 corridors with 180 km busway length in total. Table 1 lists the monthly number of passengers of TransJakarta in 2013.

Table 1. The Number of Monthly Passengers of TransJakarta on a number of corridors in 2013

Corridor	Jan	Feb	Mar	Apr	May	Jun
1	1722650	1753109	1753109	2144327	2208102	2240811
2	608449	607270	701911	656851	678055	726560
3	651398	695467	821056	793286	799330	844527
4	519565	519701	576392	580012	575861	573580
6	661385	652530	726278	726278	724563	703151
9	984900	1012136	1145375	1127795	1122989	1143005

Corridor	Jul	Aug	Sep	Oct	Nov	Dec
1	226959	1856363	2217651	2185972	2199600	2367065
2	712579	674294	730465	712963	708227	769027
3	797685	751904	862652	846839	841850	873630
4	583415	519188	646062	646242	650763	668191
6	691517	598530	708459	708459	731415	757512
9	1164793	1020026	1210573	1235085	1218115	1251486

Source: http://transjakarta.co.id/

The transportation system can be divided into two sub-systems: the supply-side system and the demand-side system. The transportation system should be designed to balance the capacity of the both sub-systems. If the level of demand is higher, then the level of service of the system will drop. If the level of the supply is higher, the system may be not operating efficiently. For this reason, monitoring the two sides of the transportation system is important for designing a cost-effective system.

To operate the transportation system efficiently and effectively, we need to monitor the both sides of the system. In the case of the BRT system, the fleet of buses is the main constituent of the supply side; meanwhile, the BRT passengers are the main constituent of the demand side. The bus fleet can now be monitored using various technologies such the Global Positioning System (GPS) [4–7]. However, the passenger monitoring system is extremely limited. This work intends to propose a monitoring system for the passenger using computer vision techniques.

Many previous studies have been performed to develop methodology to track moving objects using computer vision. In this article, those methods will be further developed for monitoring BRT passengers.

Reference [8] develops method to track the movement of many human objects in real-time utilizing the Conditional Density Propagation algorithm. Three improvement were made in his work: the use of an effective template for the human form using self-organizing map; the use of the hidden Markov model for modeling the dynamic of the human shape; and the use of a competition rule to separate a person from others. In addition, Ref. [9] study passenger detection using the characteristics of the head area. They intend to track the pedestrian movement. The tracking is achieved in two steps: applying the background difference algorithm, dynamic threshold algorithm, and the method of morphological processing to filter the image noise; and applying head matching algorithm using a mask template.

In addition, Ref. [10] develops an algorithm for estimating the volume of a passenger flow. Reference [11] discuss on tracking human motion in outdoor environment. Reference [12]develop real-time video processing on Android platform.

In this work, we develop a method for counting the number of passengers in a BRT station. The method is developed using computer vision techniques where the passengers are detected and tracked by background subtraction algorithms. We evaluate the following algorithms: Pixel-based Adaptive Segmenter algorithm [13], Godbehere-Mitsukawa-Goldberg algorithm [14], and approximated median filtering [15].

2 Methods

2.1 Design Consideration of Bus Rapid Transit System

The Bus Rapid Transit (BRT) system is the bus-in-steroid system. The system eliminates aspects that slowing down the traditional bus system in serving large number of passengers. The system delivers high performance by deploying a number of design considerations [16].

Those design considerations mainly are: the BRT bus lanes are designed to be located on the high-demand segments, off-vehicle fare collection, the busway is separated and physically protected from the mixed traffic.

The use of the dedicated lane is a very important design consideration. And, the lane is placed in the road center to minimize conflict with the mixed traffic, pedestrians spilling into the roadway, man-powered vehicles, and other conflicting factors. The off-vehicle fare collection, instead of the on-vehicle fare collection of the traditional bus system, is important to increase the passenger transfer rate.

In addition to those main design aspects, the BRT stations are designed on the median of the road and are used to share by both directions of service; see Fig. 2. Thus, the required number of stations is less and it can save cost with fewer stations. However, with this design, the BRT requires special buses which can serve passengers from the two sides of the bus.

Fig. 2. A typical design and location of the TransJakarta BRT station

2.2 Proposed Monitoring Strategy

Figure 2 shows a typical TransJakarta BRT station. The station is clearly constructed by considering the design factors discussed in Sec. 2.1. Passengers arrive on the station by using the elevated stair. The TransJakarta BRT stations tend to be narrow but long. Thus, the station can serve more than one bus simultaneously.

The proposed real-time monitoring system for such station design is shown in Fig. 3. The system consists of a central processing unit, a number of image acquisition units (CCTVs or IP cameras), wireless data communication unit, and server. The acquisition unit records the moving images of the movement of passengers across the access point. The recorded images will be sent to a central processing unit where the passenger counting will be performed. The algorithms in the CPU should be able to count the remaining passengers in the station. The data including the associated time-stamp data, will then be submitted to a server via a wireless network.

2.3 Passenger Counting Using Background Subtraction Algorithms

In the following, we will discuss three computer vision algorithms for background subtraction, which are evaluated for the purpose of passenger counting. For the detail exposition, the reader is advised to consult Ref. [15].

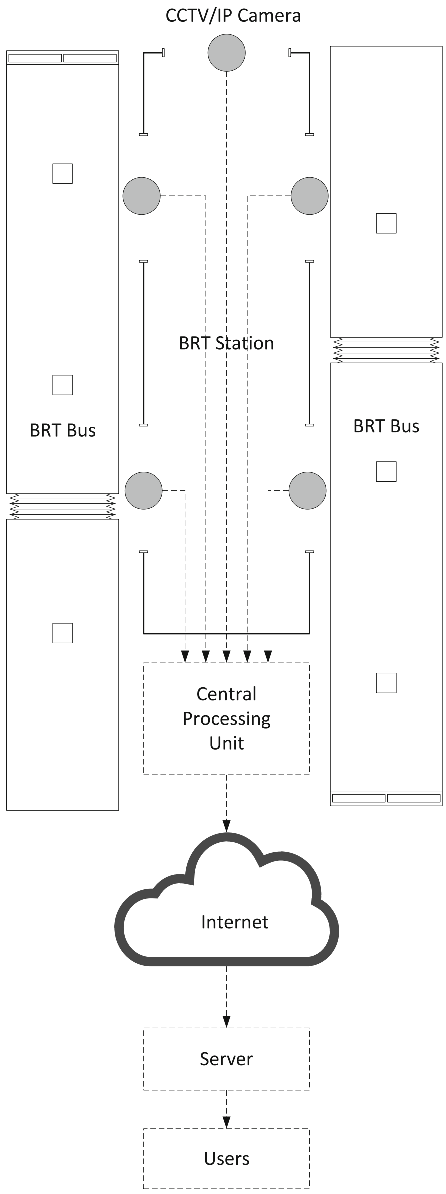

Fig. 3. The proposed passenger monitoring system for TransJakarta BRT station

In the following, we use notations: $I_t^c(x, y)$ to denote the value of channel c of the pixel at location (x, y) at time t and $B_t^c(x, y)$ is the background model.

Godbehere-Mitsukawa-Goldberg. The Godbehere-Mitsukawa-Goldberg (GMG) algorithm combines statistical background image estimation, per-pixel Bayesian segmentation, and an approximate solution to the multi target tracking problem using a bank of Kalman filters and Gale-Shapley matching. A heuristic confidence model enables selective filtering of tracks based on dynamic data. Figure 4 describes the GMG algorithm.

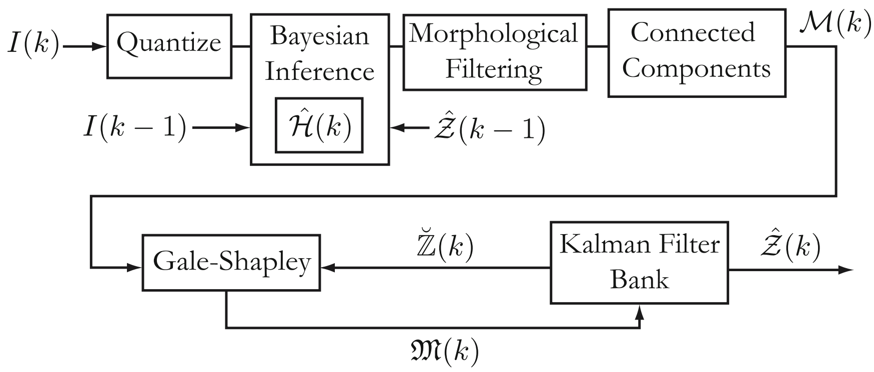

Fig. 4. GMG algorithm block diagram. An image $I(k)$ is quantized in color-space, and compared against the statistical background image model, $\hat{\mathcal{H}}(k)$, to generate a posterior probability image. This image is filtered with morphological operations and then segmented into a set of bounding boxes, $\mathcal{M}(k)$, by the connected components algorithm. The Kalman filter bank maintains a set of tracked visitors $\hat{\mathbb{Z}}(k)$, and has predicted bounding boxes for time k, $\breve{\mathbb{Z}}(k)$. The Gale-Shapley matching algorithm pairs elements of $\mathcal{M}(k)$ with $\breve{\mathbb{Z}}(k)$; these pairs are then used to update the Kalman Filter bank. The result is $\hat{\mathcal{Z}}(k)$, the collection of pixels identified as foreground. This, along with image $I(k)$, is used to update the background image model of $\hat{\mathcal{H}}(k)$. This step selectively updates only the pixels identified as background [14].

Adaptive Median Filtering. The median filtering algorithm is actually derived from the non-recursive techniques median filtering [15]. Reference [17] propose a recursive technique that is easy to estimate the median. This technique is also used for background modeling at traffic monitoring. In the algorithm, the estimated median is added by 1 if the input pixel is larger than the previos estimated median. Inversely, the median is subtracted. Mathematically, it is written:

$$B_{t+1}^{C} = \begin{cases} B_t^C + 1 & \text{if} \quad I_t^C > B_t^C \\ B_t^C - 1 & \text{if} \quad I_t^C < B_t^C \\ B_t^C & \text{if} \quad I_t^C = B_t^C \end{cases} \tag{1}$$

Pixed-based Adaptive Segmenter. Pixel-Based Adaptive Segmenter or called PBAS is a non-parametric background modeling technique [13]. The background is modeled on the basis of the observed pixel value history. The foreground decision depends on a decision threshold. The background update is based on a learning parameter. This algorithm uses dynamic per-pixels state variables and introduce dynamic controllers for each of them. The PBAS algorithm is summarized in the flowchart in Fig. 5. For the detail, we advice the reader to consult Ref. [13].

2.4 Experimental Setup

Figure 6 shows a typical access point of a typical BRT station. We draw the red virtual line and use the line to separate the region into two regions: Region A and Region B. Region A is located to the left of the line. We attach a camera to the

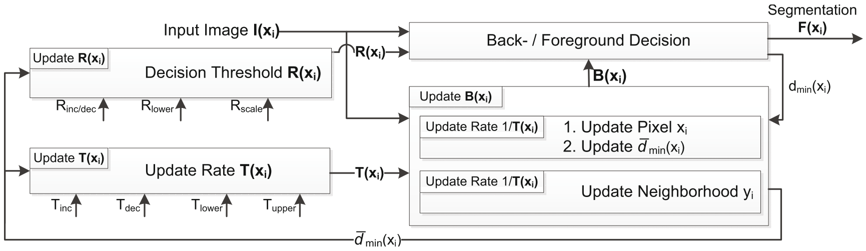

Fig. 5. PBAS algorithm block diagram. Variable $I(x_i)$ denotes the current pixel value, $B(x_i)$ is the background model, $R(x_i)$ is the per-pixel threshold, $T(x_i)$ is the learning parameter, $F(x_i)$ is the foreground segmentation mask [13].

top of that access point and record any passenger movement around the access point. When a BRT bus arrives at the station, the bus door will be align to the access point. The bus door will be in Region A. To board the bus, the passenger should walk across the red line and enter the bus. In the experiment, we record the activity in this access point for a duration of 30 minutes. We should note that in practice, passengers often wait for the bus along the red line, resulted in the counting error.

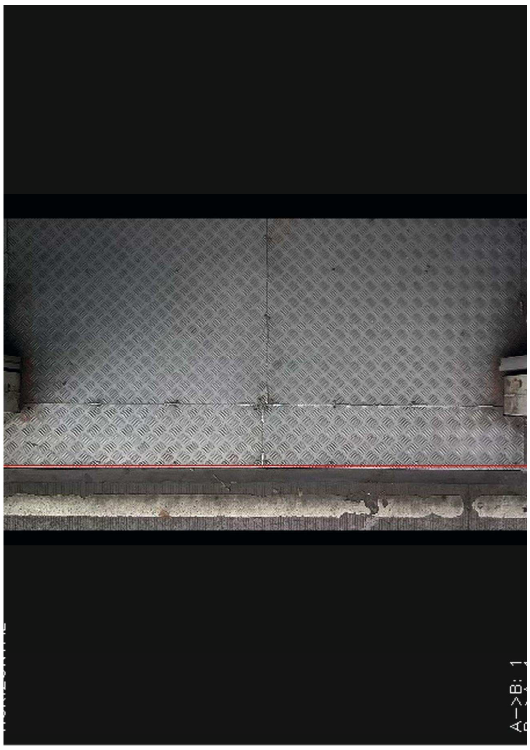

Fig. 6. An access point to a typical BRT station. The image recording system is located on the top. The red is a virtual line which is constructed to separate Region A, to the left of the line, and Region B, to the right of the line.

3 Implementation and Results

This section reports the empirical data collected during verification of the proposed method. The verification is performed as the following. In the experiment, the three algorithms are utilized and the results of each algorithms are reported.

The experimental results are tabulated in Table 2 for the PBAS, GMG, and AMF algorithms. The other results are tabulated in Table 3 for the AMF algorithm with varying the sampling rate. We should note that in this experiment the recorded image is rather low in resolution and contains high level of noise. As the results, the algorithms PBAS and GMG are not able to recall any object crossing the line and only detect the noise. In addition, the both algorithms require rather long processing time. Only the AMF algorithm can identify the object with reasonable level of accuracy and precision.

On the basis of the previous results, we further investigate the perform of the AMF algorithm by varying the sampling rate. We vary the sampling rate as 1, 3, 5, 9, and 13. The results are presented in Table III, and it indicates that the precision of the AMF algorithm tends to be strongly affected by the sampling rate. The precision level increases as the sampling rate increasing.

Table 2. The Experimental Results for PBAS, GMG, and AMF algorithms. The AMF uses the sampling rate of 1.

Parameters	PBAS Algorithm		GMG Algorithm		AMF Algorithm	
	$A \to B$	$B \to A$	$A \to B$	$B \to A$	$A \to B$	$B \to A$
The number of object captured by the algorithm	19	16	66	80	9	6
The number of correct object captured by the algorithm	0	0	0	1	2	3
The number of the actual object	3	4	3	4	3	4
Recall	0	0	0	0.25	0.67	0.75
Precision	0	0	0	0.25	0.22	0.50

Table 3. The Effect of the Sampling Rate to the Counting using AMF Algorithm

Parameters	Sampling Rate = 5		Sampling Rate = 9		Sampling Rate = 13	
	$A \to B$	$B \to A$	$A \to B$	$B \to A$	$A \to B$	$B \to A$
The number of object captured by the algorithm	11	10	12	10	12	9
The number of correct object captured by the algorithm	2	4	2	4	2	4
The number of the actual object	3	4	3	4	3	4
Recall	0.67	1.00	0.67	1.00	0.67	0.44
Precision	0.18	0.40	0.17	0.40	0.67	1.00

4 Conclusion

This research proposes a system for counting the number of passengers waiting in a BRT station. The system is designed to provide the real-time data of the number of passengers. This data is very important for the BRT fleet management. The passenger counting system utilizes computer vision technique to track the movement of passengers across the station access point. In the image of the access point, a virtual line is drew, and the passenger is counted upon crossing the line. The image can be recorded using any recording devices such as IP TV, mobile TV, or CCTV. In the designed system, the recorded image will be sent to a central processing unit for processing the passenger counting on each access point, to determine the number of the total passengers in the station, and to submit the data to a dedicated server. In the current development, only one access point is considered. The developed system is used to count the passenger crossing the access point. Then, the result is compared to the manual counting. The empirical findings suggest that the AMF algorithm provides the best results in term of the accuracy in comparison to the PBAS and GMG algorithms. The result of the AMF algorithm can also be improved by increasing the sampling rate. The required time for analysis is also lower for the AMF algorithm.

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