Intelligent Monitoring of Loading and Unloading Process in Enterprise Transport System

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Abstract. Organizations and businesses need an information infrastructure that will enable them to cope with the enormously rapid development, i.e. the process of globalization and integration of the world economy. It allows you to make accurate decisions in real-time, focus on customer dissatisfaction while maintaining competitiveness and profitability. The result is optimising the supply chain to integrate processes, approaches, systems, databases, strategies between different business partners. The consequence of e-technology is the reorganization of the enterprise's current information base, the calculation of implementation costs, and the consideration of the marketing approach as a source of information advantage. For logistics, it means a significant reduction in delivery times, increasing receipt and order processing automation. High flexibility and reliability are expected, costs do not show an increase, and the importance of planning in the chain is growing, which must be faster and more accurate. The paper aims to monitor the loading and unloading of goods from rail transport using a simulation program regarding protecting employees' health, minimizing the time required for unloading and loading pallets with goods.

Keywords: Monitoring · Simulation · Efficiency · Loading-unloading · Industry

1 Introduction

Under the term logistics system, we understand a system of transport, production and information activities that follow each other and serve to meet customers' needs in a certain place and at a certain time [1]. It is done with the help of sources of raw materials, information and workforce. By using and transforming them, we can satisfy these

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needs [2]. We can also understand the logistics system as a system of tools, constructions and organizations that implement supply chain flows between suppliers of material inputs and customers of material outputs [3]. The logistics system includes all logistics chains of the enterprise created for individual products or customers (supply, production, distribution and trade links are a subsystem), works with logistics resources (goods, people, information), which optimally deploys, focusing on customer needs. Also pursues the main goal and sub-goals of the enterprise's logistics [4, 5].

The logistics system in metallurgical enterprise can be characterized as a technical–technological system (technical means and various equipment, buildings, transport routes with personnel equipment), management system (control elements), information system (collection, processing, transmission and storage of information for the control system), communication system (technical means and transmission equipment, automation and computer technology), financial system (financial resources, transactions and financial flows) [6].

Transport is an important element of the logistics system. Transport costs make up a large part of the logistics costs. Transport logistics deals with solving logistics tasks and measures that need to be implemented to prepare and implement transport [7]. These are activities that are related to material flow, storage of finished products up to the sale. We also include information related to these activities. The transport function is irreplaceable [8]. The logistics chain from the material supplier, through the manufacturer to the customer, consists of a large part of the transport chain's transport links.

The following attributes accompany the application of logistics in transport [9]:

- the ability of transport to form networks,
- ability to transport theoretically any quantity,
- degree of transport speed,
- degree of time certainty of transport performance,
- level of comfort,
- degree of traffic safety,
- degree of provision of other services,
- the amount of rising costs.

Shipment affinity is characterized by the following features [10]:

- the place of origin and termination of the transport, or the transport route if he wants to choose it the transport user himself - the carrier,
- the usual quantity of goods transported in one consignment, expressed in weight units or number of pieces,
- speed requirements, requirements for time security of delivery of the consignment, which can be determined in time, an indication of when the consignment must be delivered concerning the exact renewal period stocks based on the optimized mode of operation of the warehouse system, for entry shipments to the next phase of production in the Just-in-Time system,
- the resilience of the consignment to the effects of traffic, including the protection of the shipment by transport cover,

- requirements for additional services,
- limits on transport costs concerning the system of circulatory processes, price goods.

Table 1 presents intelligent transport system solutions, mostly used in manufacturing enterprises.

Table 1. Intelligent transport system solutions [11].

Intelligent transport system		
Government	Enterprise	Public user
Traffic management and Guidance	Vehicle schedule/Decision support	Elaborated Geo-info service
Road planning/Law enforcement	Accidents Real-time alarming	Accurate traffic info service
Road prewarning/Emergency response	Commercial data analysis	Real-time vehicle info service
Bus supervision and Management		Parking guidance service

When we start from the generally acceptable function of logistics as a cross-cutting function, it is necessary to consider the company's cost elements [12].

These are:

- capital tied up in stocks and goods in the working process,
- space and area costs (warehouse, transhipment areas, transport routes),
- transport (internal, customer deliveries, express surcharges),
- trade (personnel costs, equipment),
- administration (order processing, information base),
- packaging, transport and storage units,
- consequential costs (unclear agreements, quality deficiencies, losses,
- damages, etc.) [13].

From the point of view of reducing costs, it is clear that knowledge of the factors of its impact must be manifested in such a logistical understanding of the service [14]:

- product characteristics (diversity of components, climate, packaging, disposal),
- procurement (ordered quantity, procurement time),
- sales (sales forecast, frequency of deliveries, delivery dates, special services),
- organization of flows (information flows, responsibilities),
- circulation times, dwell time,
- spatial distribution of undertakings, transport routes,
- habitats, company, individual areas,
- environment, regulations, competition, customer wishes, disposal of packaging, etc.

Companies force economic constraints, limited resources, competitive pressures and requirements customers to make the most efficient and productive decisions possible about the choice of mode of transport and the choice of carriers [15–18]. Considering that transport affects customer service, time of the transportation of goods, reliability of service, stocks, packaging, storage, energy consumption, pollution levels and other factors must traffic management to create the best possible strategy of the method of transport or selection carriers [19].

2 Work Methodology

Intelligent monitoring of individual work activities over time is used in companies where there has been a radical change in corporate policy. The metallurgical industry is one of the most successful and competitive industries, supplying key intermediates and end products and the solutions themselves to virtually all other sectors. It is made possible by high production standards, comprehensive infrastructure and tailor-made logistics with a clear emphasis on reliability, quality and safety. The paper uses the monitoring method of loading and unloading goods in metallurgical enterprise transport logistic supply chain railway conditions concerning the ergonomic aspect using the Static strength prediction method.

2.1 Static Strength Prediction by Loading and Unloading System

The concept consists of two basic alternatives of ergonomic and time evaluation. The first alternative combines human labour and machine loading [20]. This alternative assesses the worker's load and the total time required to load the total load containing 15 pallets. The second alternative is focused on the evaluation of pallet loading in terms of time. The following Table 2 shows the input data for the simulations.

Table 2. Input parameters.

Employer specification	
Gender	Male
Height [cm]	178
Weight [kg]	81
Material specification	
Size [mm]	590 × 490 × 650
Weight [kg]	10

The static force prediction method provides an approximate strength prediction for the subsequent use of appropriate simulation tools (Fig. 1). We will use this method to evaluate the physical work of loading and unloading goods.

Further monitoring consists (Fig. 2) of evaluating the time required to load a predefined load. Loading was simulated in a combination of manual work (loading the rear row - 5 pallets) and loading via forklift (loading the middle and front row - 10 pallets).

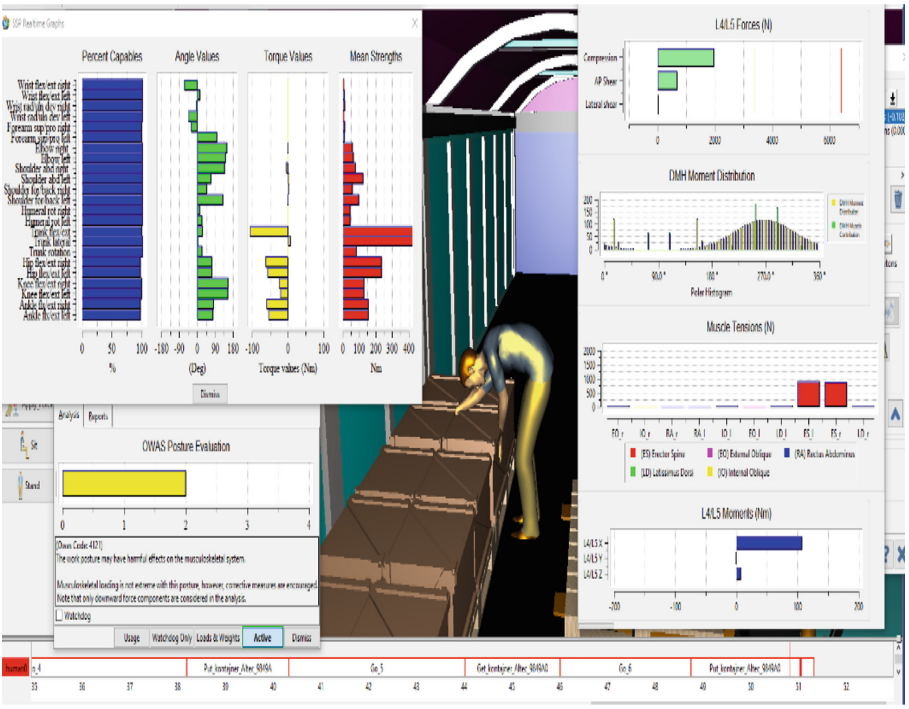

Fig. 1. Static strength prediction.

The values are given in the following Table 3.

With a combination of manual loading and forklift loading, a total time of 357.05 s was achieved, 6.79 min. This time exceeds the set loading/unloading limit of up to 5 min.

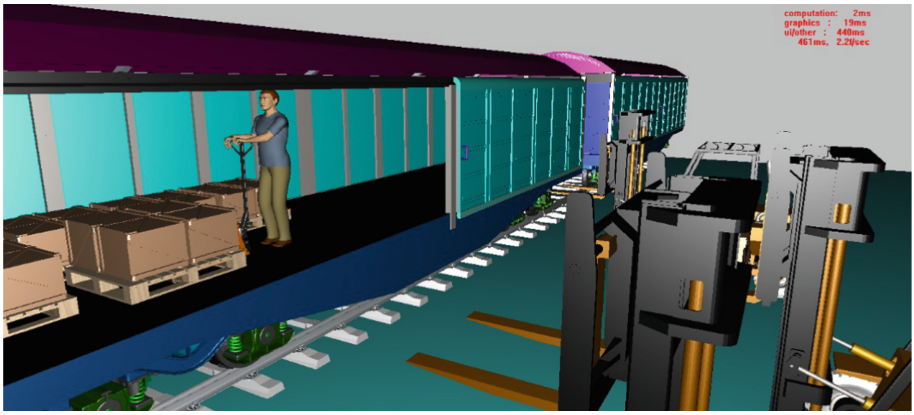

Fig. 2. Simulation of loading and unloading process

Table 3. Input parameters by SSP method.

	Operation	Time [s]
Rear row	Forklift - 5 pallets	50.15
	Manual work - 5 pallets	256.85
Middle + front row	Forklift - 10 pallets	100.20
Total time		407.20

3 Results and Discussion

Transport performance has the special character of activities to ensure the optimization of the logistics chain:

- increasing demand for transport performance,
- transport performance is many times linked to the performance of different modes of transport or services,
- transport provides decisive development impulses to economic and social entities,
- high intensity the facilities of many transport operators result in a constant supply and a significant fixed cost structure.

The way to reduce logistics costs leads through the most reliable transport [21]. Restructuring of corporate logistics systems or concentration and centralization of the warehouse network by a logistics distribution centre can also be performed [22]. Another possibility is the reorientation of goods from road transport to rail or the relocation of production plants closer to the focus of consumption. The results after simulation of human/workers activity by loading and unloading process is presented in Fig. 3.

Because the evaluated work position is - the employee's orientation in the forward bend, the evaluation was supplemented by a fourth analysis - Lower Back Analysis. This analysis estimates the spinal compression and shear forces acting on the worker's lower back. Transport logistics is of great importance within the entire logistics system.

It takes place in three basic stages of the reproductive process [23–25].

- in production: satisfying the needs caused by production technology, division of activities, cooperation of individual phases, etc.
- in circulation: relocation necessary for the implementation of economic circulation.
- in consumption: relocation of products that have already entered the consumption of tangible goods.

Transport logistics is a transport system that is suitable for the logistics management of circulation processes [26]. It is a control system which, in addition to managing the technological operations of individual activities of the circulatory process, optimizes the overall effect of the circulatory process with the help of all related information.

The technological capacity of transport logistics is affected by:

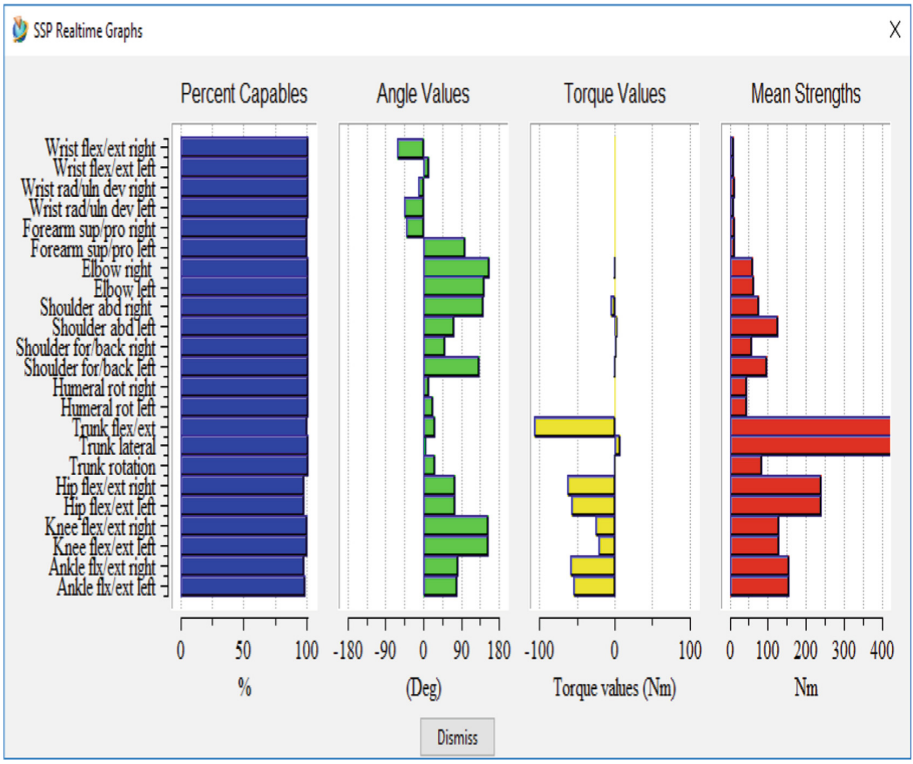

Fig. 3. Simulation of human activity by loading and unloading process.

- the capacity of stable means used by transport logistics: transport routes, transport nodes of the transport system, transport nodes in connection with the user, transport nodes in contact with different types of transport or transport systems,
- the capacity of means of transport,
- capacity compliance transport routes, transport hubs and means of transportation,
- optimal transport process technologies using a certain technical basis [27–29].

The moment distribution, muscle tensions and human forces are presented in the Fig. 4.

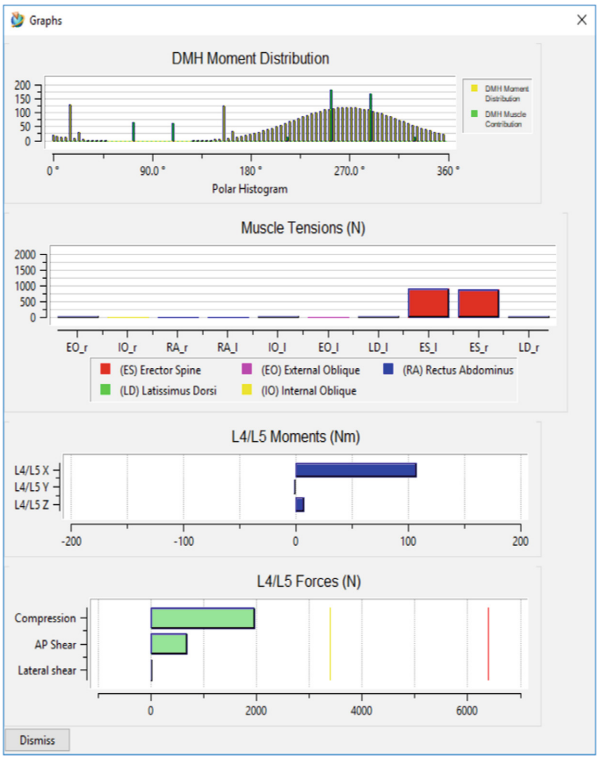

Fig. 4. The ergonomic specification.

The low back compression force of 1969.00 is below the Back Compression Action Limit of 3400 N, representing a nominal risk of low back injury for most health workers. The following Table 4 shows the overall evaluation of the loading time.

Table 4. Final operation time.

Operation	Time [s]
The arrival of the forklift to the carriage - 5 pallets	50.15
Loading with a manual forklift - 5 pallets	208.37
Loading with forklift - 10 pallets	110.40
Total time	368.92

As can be seen from the scoreboard for the second alternative, the time required to load 10 pallets with a combination of manual forklift and forklift also exceeded the required value.

Supply chain management integrates business processes from the end-user to the primary suppliers, who provide products, services and information that add value [30].

Key strategies include customer relationship management, customer service management, demand management, order fulfilment, production management, procurement, product development and commercialization, return channels [31]. Therefore, supply chain management represents a systemic approach that is interactive and complex and simultaneously requires a simultaneous assessment of a set of different links [32]. It crosses the boundaries of one company, includes links within the organization and links between organizations, where stocks are maintained and where it is necessary to perform individual parts.

4 Conclusion

The monitoring of transport logistics processes raises mainly these transport requirements, maximum flexibility in capacity and specialization, the greatest possible combination possibilities and a smooth transition of transport packaging, means of loading between different transport systems, versatile usability of means of transport, the shortest possible availability or immediate access to vehicles and objects of transport. Transportation needs to be managed in the logistics system in terms of the optimal division of labour between the various modes of transport in the logistics chain, the optimal quality of transportation and the minimization of costs for the actual relocation process and overall circulation processes. In addition to minimizing costs and increasing or optimizing the enterprise's performance, the most important goal of logistics is the maximum satisfaction of customer requirements. It is reflected in the quality of the product, the price of the product and the delivery service. The customer is the most important link in the whole chain. It provides information on the requirements for securing the supply of goods and related other services. The customer also ends the logistics chain, ensuring the movement of material and goods. Strengthening the enterprise´s market position is the main objective to which the sub-objectives are subject. These are powerful, that is, delivering the right goods, to the right place, at the right time, in quantity and quality, and economical, that is, doing it at the right cost. The future direction of our research is focused on the monitoring and evaluation of automatic loading and unloading systems by which will be minimized human errors. We can improve working time with the impact of health and environmental protection.

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References

1. Periša, M., Cvitić, I., Peraković, D., Husnjak, S.: Beacon technology for real-time in forming the traffic network users about the environment. Transport **34**, 373–382 (2019). https://doi.org/10.3846/transport.2019.10402
2. Davis, J.: 3D modeling CAD software. https://www.3dhubs.com/knowledge-base/3d-modeling-cad-software/. Accessed 15 Oct 2020
3. Matulić, I., Msa, M., Peraković, D.: Information and communication infrastructure for the organisation of railway passenger transport. In: Čokorilo, O. (ed.) Proceedings of the Second International Conference on Traffic and Transport Engineering ICTTE. City Net Scientific Research Center Ltd., Belgrade, Serbia, pp 410–419 (2014)
4. Optimizing Target Detection and Tracking Stability. https://library.vuforia.com/features/images/image-targets/best-practices-for-designing-and-developing-image-based-targets.html. Accessed 21 Oct 2021
5. Cvitić, I., Peraković, D., Periša, M., Husnjak, S.: An overview of distributed denial of service traffic detection approaches. Promet - Traffic Transp. **31**, 453–464 (2019). https://doi.org/10.7307/ptt.v31i4.3082
6. European Commission: Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community (2008)
7. Lyons, G., Jain, J., Weir, I.: Changing times – a decade of empirical insight into the experience of rail passengers in Great Britain. J. Transp. Geogr. **57**, 94–104 (2016). https://doi.org/10.1016/j.jtrangeo.2016.10.003
8. Transport Focus: Rail passengers' priorities for improvements (2014). https://www.transportfocus.org.uk/publication/rail-passengers-priorities-for-improvements-october-2014/. Accessed 17 Sep 2021
9. Peña Miñano, S., et al.: A review of digital way finding technologies in the transportation industry. In: Advances in Trans disciplinary Engineering. IOS Press BV, pp 207–212 (2017)
10. Camacho, T.D., Foth, M., Rakotonirainy, A.: Pervasive technology and public transport: opportunities beyond telematics. IEEE Pervasive Comput. **12**, 18–25 (2013). https://doi.org/10.1109/MPRV.2012.61
11. Nagyova, A., Pacaiova, H., Markulik, S., et al.: Design of a model for risk reduction in project management in small and medium-sized enterprises. Symetry-Basel **13**(5), 763 (2021). https://doi.org/10.3390/sym13050763
12. Shao, X., Liu, J.J., Gao, Z.M., Wang, P.: A study on intelligent onboard rail passenger service systems. In: Ni, Y.Q., Ye, X. (eds.) Proceedings of the 1st International Workshop on High-Speed and Intercity Railways. Springer, Heidelberg, pp 69–82 (2012). https://doi.org/10.1007/978-3-642-27960-7_7
13. Straka, M., Khouri, S., et al.: Utilization of computer simulation for waste separation design as a logistics system. Int. J. Simul. Model. **17**(4), 83–596 (2018). https://doi.org/10.2507/IJSIMM17(4)444
14. Kornaszewski, M., Pniewski, R.: The impact of new telematics solutions on the safety of railway traffic on the example of modern simulators railway traffic control devices. In: Mikulski, J. (ed.) Development of Transport by Telematics, pp. 32–43. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-27547-1_3
15. European Commission: COMMISSION REGULATION (EU) No 454/2011 of 5 May 2011 on the technical specification for interoperability relating to the subsystem 'telematics applications for passenger services' of the trans-European rail system (Text with EEA relevance) (2011)

16. Zorić, P., Mikulčić, M., Musa, M., Kuljanić, T.M.: Analysis of available information and communication solutions and services for railway passenger information in the EU. In: Knapčíková, L., Peraković, D., Behúnová, A., Perisa, M. (eds.) 5th EAI International Conference on Management of Manufacturing Systems. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-67241-6_29
17. Peraković, D., Periša, M., Petrović, M., Cvitić, I., Zorić, P.: Studija implementacije sustava informiranja putnika na željezničkoj mreži. Zagreb, Croatia (2020)
18. Peraković, D., Periša, M., Cvitić, I., Brletić, L.: Innovative services for informing visually impaired persons in indoor environments. EAI Endorsed Trans. Internet Things **4**, e4 (2018). https://doi.org/10.4108/eai.5-3-2019.156720
19. Pacaiova, H., Sinay, J., Markulik, S., et al.: Measuring the qualitative actors on copper wire surface. Measurement **109**, 359–365 (2017). https://doi.org/10.1016/j.measurement.2017.06.002
20. Periša, M., Kuljanić, T.M., Cvitić, I., Kolarovszki, P.: Conceptual model for informing user with innovative smart wearable device in industry 4.0. Wireless Netw. **27**(3), 1615–1626 (2019). https://doi.org/10.1007/s11276-019-02057-9
21. Meinig, M., Sukmana, M.I., Torkura, K.A., Meinel, C.: Holistic strategy-based threat model for organizations. Proc. Comput. Sci. **151**, 100–107 (2019)
22. Islam, M.A., Vrbsky, S.V.: Transaction management with tree-based consistency in cloud databases. Int. J. Cloud Comput. **6**(1), 58–78 (2017)
23. Gou, Z., Yamaguchi, S., et al.: Analysis of various security issues and challenges in cloud computing environment: a survey. Identity Theft: Breakthroughs in Research and Practice, pp. 221–247. IGI global (2017)
24. Olakanmi, O.O., Dada, A.: An efficient privacy-preserving approach for secure verifiable outsourced computing on untrusted platforms. Int. J. Cloud Appl. Comput. (IJCAC) **9**(2), 79–98 (2019)
25. Song, D., Shi, E., Fischer, I., Shankar, U.: Cloud data protection for the masses. Computer **45**(1), 39–45 (2012)
26. Tran, H.-Y., Jiankun, H.: Privacy-preserving big data analytics a comprehensive survey. Parallel Distrib. Comput. **134**, 207–218 (2019)
27. Hugos, M.H., Hulitzky, D.: Business in the Cloud: What Every Business Needs to Know About Cloud Computing. John Wiley & Sons, Hoboken, p. 139 (2010)
28. Mehmood, U., Moser, I., Jayaraman, P.P., Banerjee, A.: Occupancy estimation using Wi-Fi: a case study for counting passengers on busses. In: IEEE 5th World Forum on Internet of Things, pp 165–170 (2019)
29. Prandi, C., Nunes, N., Ribeiro, M., Nisi, V.: Enhancing sustainable mobility awareness by exploiting multi-sourced data: the case study of the Madeira Islands. In: Sustainable Internet and ICT for Sustainability (SustainIT), Funchal, pp. 1–5 (2017)
30. Oransirikul, T., Nishide, R., Piumarta, I., Takada, H.: Measuring bus passenger load by monitoring Wi-Fi transmissions from mobile devices. Procedia Technol. **18**, 120–125 (2014)
31. Le, T.V., Song, B., Wynter, L.: Real-time prediction of length of stay using passive Wi-Fi sensing. In: 2017 IEEE International Conference on Communications (ICC), Paris, pp. 1–6 (2017)
32. Grgurević, I., Juršić, K., Rajič, I.: Review of automatic passenger counting systems in public urban transport. In: Proceedings of 5th EAI International Conference on Management of Manufacturing Systems, EAI MMS 2020, Cyberspace (2020)