Available online at www.sciencedirect.com

ScienceDirect

IFAC PapersOnline CONFERENCE PAPER ARCHIVE

IFAC PapersOnLine 54-1 (2021) 942–947

Social Infrastructure supporting Ambient Assisted Living in a Smart Silver City: Literature Review and Research Agenda

David Bogataj*, Valerija Rogelj**, and Alenka Temeljotov Salaj*****

*University of Ljubljana, School of Economics and Business, 1000 Ljubljana, Slovenia
(e-mail: david.bogataj@ef.uni-lj.si)
**Institute INRISK, 8210 Trebnje, Slovenia
(e-mail: valerija.rogelj@inrisk.net)
*** Norwegian University of Science and Technology, 7491 Trondheim, Norway
(e-mail: alenka.temeljotov-salaj@ntnu.no)

Abstract: Cities in EU member states are ageing. The increasing number of older urban residents have difficulties with basic activities of daily living due to physical and cognitive functional decline. Therefore, the demand for long-term care services in urban areas is rising. In the last 20 years, emerging technologies such as wireless communication, Internet of Things (IoT), sensors, ambient intelligence and cloud computing have opened up the possibilities of developing cyber-physical systems with various applications supporting older adults to remain physically and mentally active and live autonomously while being engaged in their communities. This paper shows that social infrastructure is an under-researched area of a smart city compared with digital infrastructure, transport infrastructure and utilities. This paper aims to review the digital transformation of social infrastructure for older adults in a smart city based on ambient assisted living technologies and propose a future research agenda.

Keywords: smart city, ambient assisted living, health care, social care, social infrastructure

Acknowledgement: The authors acknowledge the project J6—9396: DEVELOPMENT OF SOCIAL INFRASTRUCTURE AND SERVICES FOR COMMUNITY BASED LONG-TERM CARE was financially supported by the Slovenian Research Agency in the framework of the research core funding No. P5—0364.

1. INTRODUCTION

A smart city is an urban area where sensors and sensor networks connected to smart devices embedded in Cyber-Physical Systems (CPS) are deployed to collect data using the Internet of Things (IoT) as the infrastructure (Hnetynka, 2017) and then use insights gained from that data to manage assets, resources and services efficiently (Kuru and Ansell, 2020). Smart cities are using information technologies collected data (Suryanegara, Prasety, Andriyanto, and Hayati, 2019) to improve the efficiency and effectiveness of the operations across the city. The data collected by different types of sensors are created by citizens, vehicles, devices, facilities and other assets (Du, Santi, Xiao, Vasilakos, and Fischione, 2019). Complex communication architecture (Li, Cai, Deng, and Yao, 2019) is required to process and analyse collected data. A smart city uses information technology to monitor and manage utilities (Camero and Alba, 2019), power plants and energy networks (Shakoor, Kaleem, Baig, Chughtai, Duong, and Nguyen, 2019), traffic and transportation systems (Kulandaivel, Balasubramaniam, Al-Turjman, Mostarda, Ramachandran, and Patan, 2019), waste collection and circular economy (Aceleanu, Serban, M.-C. Suciu, in T. I. Bitoiu, 2019), land use (Duan, Fan, Liu and Hou, 2020), zoning (Hao, Zhang, Duan, Zhao, Guo, and Park, 2020), air quality (Marques and Pitarma, 2019) and environmental quality management (Marques and Pitarma, 2019) to improve the wellbeing and health of residents (Laamarti, Badawi, Ding, Arafsha, Hafidh, and Saddik, 2015).

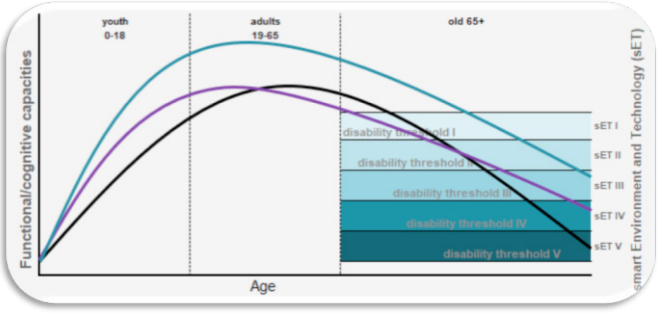

Fig. 1. The decline of functional capacities of older adults and support for autonomy and independence that ambient assisted living environment can provide.

The independence and autonomy of residents of smart cities do not depend exclusively on their functional capacities (Fig. 1) (physical and cognitive abilities) but also on the social infrastructure, services (Szander et al., 2017, 2018; Usenik and Bogataj, 2005; Kovačić et al., 2015, 2017) with the appropriate timing of delivery (Bogataj and Bogataj (2004, 2007) and living environment (housing and public spaces) (Drobne and

10.1016/j.ifacol.2021.08.111

Bogataj, 2005, 2012, 2013, 2015, 2017; Drobne et al., 2011, 2011a; Bogataj et al., 2011, 2012; Lisec et al., 2008) and services. If appropriately developed social infrastructure has potential to improve social sustainability of smart cities (Grum and Kobal Grum, 2020). Therefore, the investments in specialised housing as part of social infrastructure should be determined systematically and partly publicly funded from property taxes (Janež et al., 2016, 2018; Janež and Bogataj, 2018).

.2. LITERATURE REVIEW

Due to a decline in cognitive capacities and sensory functions, the living environment with barriers of the built environment can become dangerous for residents. The ambient intelligence (Gams, Gu, Harma, Munoz, and Tam, 2019) can mitigate the risk to which residents are exposed due frailty and decline in physical and cognitive functional capacities.. Smart cities are using innovative approaches to health care and long-term care (Gandarillas and Goswami, 2018) based on technologies supporting the adaptive accessibility of everyday objects (Krishnan, Vijayakumar, Kumar, Balaji, Ghose, and Venkatachari, 2018) and ambient assisted living (AAL) technologies such as wearable devices (Belmonte-Fernandez, Puertas-Cabedo, Torres-Sospedra, Montoliu-Colas, and Trilles-Oliver, 2017) using IoT as infrastructure (Mulero et al., 2017) for the monitoring of the activities of older adults (Marques and Pitarma, 2016). The independence and autonomy of older residents do not depend only on their physical and cognitive abilities) but also on the living environment and service.

Remote and non-invasive monitoring of the elderly in a smart city context (Bellagente et al., 2018) using activity recognition systems (Almeida and Azkune, 2017) embedded in smart environments such as Activity Recognition as a Service embedded in a Smart Home using Ambient Assisted Living Technologies (Fan et al., 2017), IoT architecture (Mulero et al., 2018), and machine learning technology (Marchenko et al., 2020) can be deployed for the recognition of the activities of daily living (Nef et al., 2017). Further, these have the potential to mitigate the risk to which older adults are exposed in a community and therefore enable a growing number of frail older adults with declining functional capacities to live longer in their communities and postpone moving to a nursing home. From the urban perspective, facility management explores the possibilities for the identification of the core facilities needed in communities and core services requirements (Lindkvist et al., 2020) Concerning housing conditions, the smart facilities can help in the recognition of external hazards in the physical environment, assessing the physical path patterns and risks, helping in intervention strategies and assisting centres with data for better elderly care. The use of ambient assisted technologies can facilitate autonomy and independence for very old (80+) urban dwellers and improve their mobility and social engagement, therefore enhancing the quality of life in old age. Technologies will enable older adults to live in the community for as long as possible and postpone moving to a nursing home. Smart cities containing AAL-supported environments with an embedded ecosystem of various sensors, wireless networks, mobile devices, computers and software applications for community support, health monitoring and a supportive age-friendly living environment are adapted to the needs and functional capacities of older adults (Fig. 2).

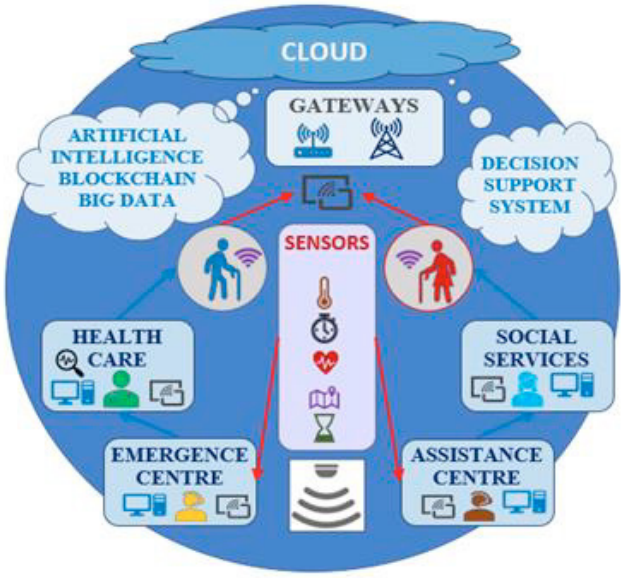

Fig. 2. Ambient assisted living digital platform as social infrastructure of a smart city.

Sensing systems for smart living (Bellagente et al., 2017) and AAL technologies are not systematically embedded in the regional health and social infrastructure. In a single ecosystem where all solutions are connected, heterogeneity in IoT systems needs to be overcome (Kazmi, Jan, Zappa, and Serrano, 2017). The single standard would enable the development of smart districts (Schulz, Arnold, and Kirsch, 2014) where the integration of health care and social care services would be possible on the district and neighbourhood levels. This would allow the linking of AAL-generated data with the data of health care and social care services in an ageing society (Mulero, Urosevic, Almeida and Tatsiopoulos, 2018), enabling improved data management and data analysis, which would be the first step towards establishing age-friendly, human-centred cities (Gudowsky, Sotoudeh, Capari, and Wilfing, 2017) supported by the Cognitive Internet of Everything (Jamnal, Liu, Fan, and Ramachandran, 2017). One possible approach is using the APEX framework in the design of AAL systems (Campos, Abade, Silva, and Harrison, 2017).

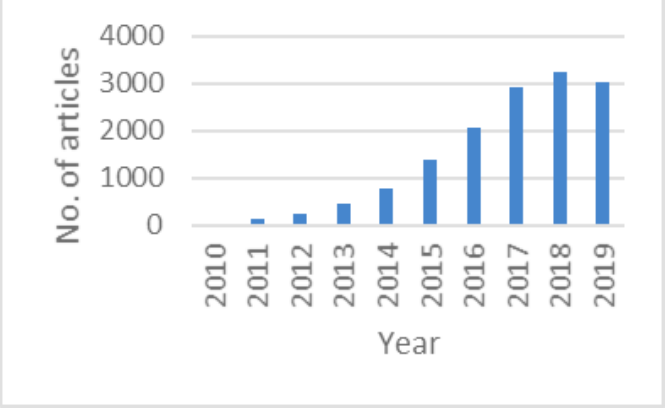

Fig. 3. The dynamics of publications on topics of smart cities in the journals indexed by WoS in the last 10 years

In the last 25 years, 15.720 papers were published in WoS-indexed journals on the topic of smart city, but only 32 articles on topics of smart cities and AAL.

In the last six years, only 33 articles on topics of smart city and ambient assisted living were published in WoS-indexed journals.

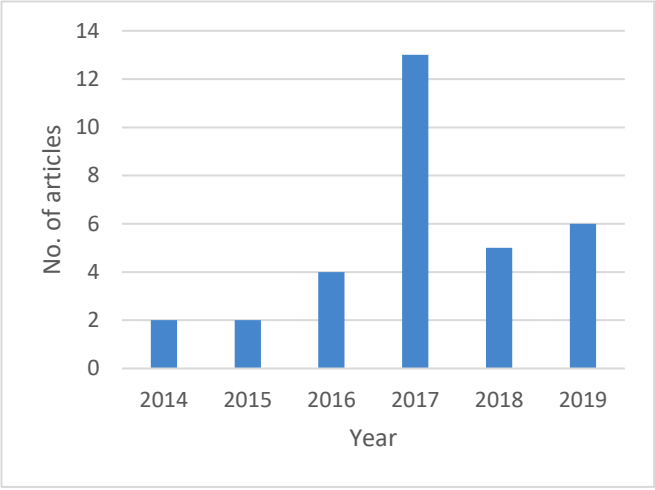

Fig. 4. The dynamics of publications on topics of smart cities and ambient assisted living in the journals indexed by WoS in the last 10 years.

In the WoS, on topics of smart cities and AAL, there are 18 proceedings papers, 15 articles and one book chapter.

TABLE 1: RESEARCH AREAS IN WOS ON SMART CITIES AND AMBIENT ASSISTED LIVING

Research Areas	No. of papers	% of 32
COMPUTER SCIENCE	19	59.375
ENGINEERING	15	46.875
TELECOMMUNICATIONS	9	28.125
INSTRUMENTS INSTRUMENTATION	4	12.5
CHEMISTRY	3	9.375
BUSINESS ECONOMICS	2	6.25
COMMUNICATION	1	3.125
ENERGY FUELS	1	3.125
ENVIRONMENTAL SCIENCES ECOLOGY	1	3.125

3. IDENTIFIED GAPS AND RESEARCH AGENDA

The main challenge of the development of AAL in smart cities is how to achieve the non-invasive monitoring of the elderly (Vegesna, Tran, Angelaccio, and Arcona, 2017) in a smart city context. By the deployment of mobile applications (Caione, Fiore, Mainetti, Manco, and Vergallo, 2017), policymakers and managers of social infrastructure can exploit the IoT infrastructure of a smart city for the orchestration of mobile device sensors to detect patterns of outdoor and indoor user movement. Development of context-aware computing (Wlodarczak, Soar, and Ally, 2016) and wireless system integration (Roy, Chowdhury, Ghosh, and Bandyopadhyay, 2019) are the basis for the development of indoor and outdoor context-aware environments (Lopez-Iturri, Aguirre, Azpilicueta, Astrain, Villandangos, and Falcone, 2017). One of the main challenges in the deployments of smart environments is ensuring the security of personal data generated by e-health and AAL applications that use IoT as their infrastructure (Minoli, Sohraby, and Occhiogrosso, 2017).

In the literature review, we identified the following gaps related to assistive technologies:

1. Due to lack of a systematic approach towards social innovations (Roblek, Mesko, Dimovski and Peterlin, 2019) in smart cities there is knowledge gap regarding the influence of smart assistive technologies on digital transformation (Zagorsek, Dimovski and Skerlavaj, 2009), value creation (Bozic and Dimovski, V, 2019) and sustainability of urban care networks (Peterlin, Dimovski, Tvaronaviciene, Grah and Kaklauskas, 2018;).

We do not know how the characteristics of various assistive technologies influence the independence and autonomy of older residents and how technology led organizational learning (Arh, Blazic and Dimovski, 2012) can support transfer of knowledge regarding best practices (Skerlavaj et al. 2007; de Pablo Gonzalez del Campo et al.,2008; Zagorsek, Dimovski and Skerlavaj, 2009)

2. A model of risk mitigation in smart cities regarding events leading to ill health and disability due to real-time control provided by assistive technologies does not exist yet. Urban facility management has important role in reducing a hazard to which older citizens are exposed and can therefore contribute to development of healthy cities (Nijkamp and Mobach, 2020). The research question is how the location of social facilities (Kovacic and Bogataj, 2013; Kovacic, Hontoria, Ros-McDonnell, and Bogataj, 2015) influences time delays in the provision of services (Bogataj and Usenik, 2005; Usenik and Bogataj, 2005; Bogataj, Grubbstrom, and Bogataj, 2011; Bogataj and Grubbstrom, 2012; Bogataj and Grubbstrom, 2013) in interventions and therefore the quality of service (Bogataj and Bogataj, 2007; Hernaus, Skerlavaj and Dimovski, 2008).

3. A legal framework for the development of smart cities' social infrastructure does not exist yet. This is necessary, especially regarding data protection, considering the users are fragile older adults.

4. A model of the public financing of the development of social infrastructure in smart cities and influence of change in taxation policies (Janež, Bogataj, and Drobne, 2016; Janež, Bogataj, and Drobne; 2016; Janež, Drobne, and Bogataj, 2018; Janež and Bogataj, 2018) does not exist yet. The research question is how the social infrastructure of the smart city influences land valuation (Bogataj, Suban, and Drobne, 2011).

5. A model for quantifying the demand for AAL-supported services in the indoor environment and public spaces does not yet exist. The demand for AAL environments embedded with AAL technologies to support older adults with decreasing functional capacities is expected to grow in the next 50 years. Research in the field of AAL has intensified in the last 10 years, as can be seen from the number of publications on the topics of AAL in the previous 10 years. Therefore, we can determine the needed structure of housing stocks based on multiple decrement approaches, developed by using the principles of actuarial mathematics.

The AAL technologies of smart cities are not connected to the regional health and care systems, which is decreasing their usefulness and uptake. There is insufficient understanding of the effects of AAL technologies on the physical and social context of urban environments generated by smart city technologies. Thus, more evidence is needed on how the physical and social environment can be supported by AAL technologies to affect the health and wellbeing of older residents in a smart city.

4. CONCLUSIONS

Innovations in health care and digital transformation of the support of older adults will be an essential part of how European cities will maintain and improve the quality of life for their growing number of older residents. Due to a decline in physical capacities, older adults suffer decreased mobility and frailty and are exposed to the risks of falls and social isolation. The organisation of care for older adults in AAL technology-supported environments reduces the risks of falls, social exclusion and loneliness. The development of such situations has the potential to postpone relocation to nursing homes and therefore considerably lower the cost of health care and long-term care for older adults. Currently, there are no papers in the WoS that measure the effectiveness of different AAL technologies. When studying systems supporting active and healthy ageing in ageing societies, their performance should be measured using a competing risk model. Using this model, new insights can be studied regarding how the provision of supply chain, community logistics, digital infrastructure, ambient intelligence technologies, assistance centres, health care and long-term care services and different environments supported by various AAL technologies influence the time of relocation to a nursing home.

. REFERENCES

Aceleanu M. I., A. C. Serban, M.-C. Suciu, and T. I. Bitoiu, (2019) The Management of Municipal Waste through Circular Economy in the Context of Smart Cities Development, IEEE Access, Vol. 7, pp. 133602–133614,

Almeida A. and G. Azkune, (2017) Activity Recognition Approaches for Smart Cities The City4Age use case. New York: Ieee, pp. 560–564.

Arh, T., Blazic, B. J. and Dimovski, V. (2012). The impact of technology-enhanced organisational learning on business performance: An empirical study. Journal of East European Management Studies, 17(3), 369–383.

Bellagente P. et al. (2017), Easy Implementation of Sensing Systems for Smart Living. New York: Ieee, , pp. 337–342.

Bellagente P. et al., (2018) Remote and non-invasive monitoring of elderly in a smart city context. New York: Ieee, pp. 128–133.

Belmonte-Fernandez O., A. Puertas-Cabedo, J. Torres-Sospedra, R. Montoliu-Colas, and S. Trilles-Oliver, (2017) An Indoor Positioning System Based on Wearables for Ambient-Assisted Living“, Sensors, Vol. 17, no. 1, pp. 36

Bogataj, L., and Bogataj, M. (2007). The study of optimal additional investments in capacities for reduction of delays in value chain. International Journal of Production Economics, 108(1–2), 281–290.

Bogataj, M., Suban, D. T., and Drobne, S. (2011). Regression-fuzzy approach to land valuation. Central European Journal of Operations Research, 19(3), 253–265.

Bogataj, M., Bogataj, L. (2004). On the compact presentation of the lead times perturbations in distribution networks. International journal of production economics, 88(2), 145-155.

Caione A., A. Fiore, L. Mainetti, L. Manco, in R. Vergallo, (2017) Exploiting an IoT local middleware for the orchestration of mobile device sensors to detect outdoor and indoor user positioning, in 2017 25th International Conference on Software, Telecommunications and Computer Networks (softcom), D. Begusic, N. Rozic, J. Radic, in M. Saric, Ur. New York: Ieee, pp. 489–493.

Camero A. and E. Alba, (2019) Smart City and information technology: A review, Cities, Vol. 93, pp. 84–94, okt.

Campos, J.C., T. Abade, J. L. Silva, and M. D. Harrison, (2017). Don’t go in there! using the APEX framework in the design of ambient assisted living systems, J. Ambient Intell. Humaniz. Comput., Vol. 8, no. 4, pp. 551–566

Cavallaro, G., Riedel, M., Richerzhagen, M., Benediktsson, J. A. and Plaza, A. (2015). On Understanding Big Data Impacts in Remotely Sensed Image Classification Using Support Vector Machine Methods. Ieee Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8(10), 4634–4646.

de Pablo Gonzalez del Campo, J. D. S., Guadamillas Gomez, F., Dimovski, V., and Skerlavaj, M. (2008). Exploratory study of organizational learning network within a Spanish high-tech company. Zbornik Radova Ekonomskog Fakulteta U Rijeci-Proceedings of Rijeka Faculty of Economics, 26(2), 257–277.

Minoli D. and K. Sohraby, and B. Occhiogrosso, (2017) IoT Security (IoTSec) Mechanisms For e-Health and Ambient Assisted Living Applications. New York: Ieee, pp. 13–18.

Drobne, S. and Bogataj, M. (2005). Intermunicipal gravity model of Slovenia. SOR '05 proceedings, Ljubljana: SDI-SOR 2005, 207–212.

Drobne, S. and Bogataj, M. (2012). A method to define the number of functional regions: An application to NUTS 2 and NUTS 3 levels in Slovenia. Geodetski vestnik 56(1), 105–150.

Drobne, S. and Bogataj, M. (2013). Evaluating functional regions for servicing the elderly. SOR '13 proceedings. Ljubljana: SDI-SOR, 331–336.

Drobne, S. and Bogataj, M. (2015). Optimal allocation of public service centres in the central places of functional regions. IFAC-PapersOnLine, 48(3), 2362–2367.

Drobne, S. and Bogataj, M. (2017). The impact of public investments in facilities on the potential housing market for older persons. Facilities, 35(7/8): 422–435.

Drobne, S., Bogataj, M., Krivic, M. and Lisec, A. (2011). Dynamics and local policy in commuting: attractiveness and stickiness of Slovenian municipalities. SOR '11 proceedings. Ljubljana: SDI-SOR. 323–328.

Drobne, S., Bogataj, M., Tuljak Suban, D. and Železnik, U. (2011). Regression-neuro-fuzzy approach to analyse distance function in internal inter-regional migrations in EU countries. SOR '11 proceedings. Ljubljana: SDI-SOR, 171–176.

Du, R., Santi, P., Xiao, M., Vasilakos, A. V., and Fischione, C. (2019). The Sensable City: A Survey on the Deployment and Management for Smart City Monitoring. Ieee Communications Surveys and Tutorials, 21(2), 1533–1560.

Duan Y.-Q., X.-Y. Fan, J.-C. Liu, and Q.-H. Hou, (2020) Operating Efficiency-Based Data Mining on Intensive Land Use in Smart City, IEEE Access, Vol. 8, pp. 17253–17262,

Fan X. et al., (2017) Activity Recognition as a Service for Smart Home Ambient Assisted Living Application via Sensing Home. New York: Ieee, pp. 54–61.

Ferrara E. et. all, (2019) An AI Approach to Collecting and Analyzing Human Interactions With Urban Environments, IEEE Access, Vol. 7, pp. 141476–141486

Gandarillas M. A. and N. Goswami, (2018) Merging current health care trends: innovative perspective in aging care", Clinical Interventions in Aging, vol. 13, pp. 2083–2095

Grubbstrom, R. W., Bogataj, M., and Bogataj, L. (2010). Optimal lotsizing within MRP Theory. Annual Reviews in Control, 34(1), 89–100.

Grum, B. and Kobal Grum, D. (2020). Concepts of social sustainability based on social infrastructure and quality of life. Facilities, vol. 38, iss. 11/12, pp. 783-800.

Gudowsky N., M. Sotoudeh, L. Capari, and H. Wilfing, (2017) Transdisciplinary forward-looking agenda setting for age-friendly, human centered cities, Futures, Vol. 90, pp. 16–30,

Hao F., J. Zhang, Z. Duan, L. Zhao, L. Guo, and D.-S. Park, (2020) Urban Area Function Zoning Based on User Relationships in Location-Based Social Networks", IEEE Access, Vol. 8, pp. 23487–23495

Hnetynka P., (2017) Software Abstractions and Architectures for Smart Cyber-Physical Systems. New York: Ieee,, pp. 3–3.

Jamnal G.S., X. Liu, L. Fan, and M. Ramachandran, (2017), Cognitive Internet of Everything (CIoE): State of the Art and Approaches. Hersey: Igi Global, pp. 277–309.

Janež, P. and Bogataj, M. (2018). The impact of real estate taxations on the inter-municipal migration which influences the housing construction dynamics. Engineering digital transformation. Lecture notes in management and industrial engineering, Cham: Springer: 41–48.

Janež, P., Bogataj, M. and Drobne, S. (2016). Impact of the real estate taxation and municipal revenue on dynamics of internal migration : case study for city Municipal of Ljubljana. Geodetski vestnik 60(4), 644–684.

Janež, P., Drobne S. and Bogataj, M. (2018). Forecasting dynamics of daily commuting to work to other municipality in the case of changing taxation policies. Lecture notes in management and industrial engineering. Cham: Springer: 105–112.

Kazmi A., Z. Jan, A. Zappa, and M. Serrano, (2017) Overcoming the Heterogeneity in the Internet of Things for Smart Cities, v Interoperability and Open-Source Solutions for the Internet of Things (inteross-Iot 2016), Vol. 10218, I. P. Zarko, A. Broering, S. Soursos, in M. Serrano, Ur. Cham: Springer International Publishing Ag, pp. 20–35.

Kovačič, D., Usenik, J., and Bogataj, M. (2017). Optimal decisions on investments in Urban Energy Cogeneration plants—Extended MRP and fuzzy approach to the stochastic systems. International Journal of Production Economics, 183, 583–595.

Kovačič, D., Hontoria, E., Ros-McDonnell, L., and Bogataj, M. (2015). Location and lead-time perturbations in multi-level assembly systems of perishable goods in Spanish baby food logistics. *Central European Journal of Operations Research*, 23(3), 607–623.

Krishnan B., A. Vijayakumar, H. Kumar, R. Balaji, A. Ghose, and S. R. Venkatachari, (2018) Digital Citizen Engagement Framework: An Approach to Citizen Centric Smart Cities of the Future, in Intelligent Environments, Vol. 23, I. Chatzigiannakis, Y. Tobe, P. Novais, in O. Amft, Ur. Amsterdam: Ios Press, pp. 28–37.

Kulandaivel R., M. Balasubramaniam, F. Al-Turjman, L. Mostarda, M. Ramachandran, and R. Patan, (2019) Intelligent Data Delivery Approach for Smart Cities Using Road Side Units, IEEE Access, Vol. 7, pp. 139462–139474

Kuru K. and D. Ansell, (2020) TCitySmartF A Comprehensive Systematic Framework for Transforming Cities Into Smart Cities, IEEE Access, Vol. 8, pp. 18615–18644

Laamarti F., H. F. Badawi, Y. Ding, F. Arafsha, B. Hafidh, and A. El Saddik, (2015) An ISO/IEEE 11073 Standardized Digital Twin Framework for Health and Well-Being in Smart Cities, IEEE Access, Vol. 8, pp. 105950–105961, 2020

Leung, C. K., Braun, P., and Cuzzocrea, A. (2019). AI-Based Sensor Information Fusion for Supporting Deep Supervised Learning. Sensors, 19(6), 1345.

Li, D., Cai, Z., Deng, L., and Yao, X. (2019). IoT complex communication architecture for smart cities based on soft computing models. Soft Computing, 23(8), 2799–2812.

Li, Z., Zhu, S., Hong, H., Li, Y., and El Saddik, A. (2017). City digital pulse: A cloud based heterogeneous data analysis platform. Multimedia Tools and Applications, 76(8), 10893–10916.

Lindkvist, C., Temeljotov Salaj, A., Collins, D., Bjørberg, S. and Haugen, T.B. (2020), Exploring urban facilities management approaches to increase connectivity in smart cities, Facilities,

Lopez-Iturri P., E. Aguirre, L. Azpilicueta, J. J. Astrain, J. Villandangos, and F. Falcone, (2017) Challenges in Wireless System Integration as Enablers for Indoor Context Aware Environments, Sensors, Vol. 17, no. 7, pp. 1616

Marchenko, A., Temeljotov Salaj, A., Rizzardi, V., and Oksavik, O. (2020), The Study of Facial Muscle Movements for Non-Invasive Thermal Discomfort Detection via Bio-Sensing Technology. Part I: Development of the Experimental Design and Description of the Collected Data, Applied Sciences, 2020, 10, 7315

Marques G. and R. Pitarma, (2016) An Indoor Monitoring System for Ambient Assisted Living Based on Internet of Things Architecture, Int. J. Environ. Res. Public Health, Vol. 13, no. 11, pp. 1152

Marques G. and R. Pitarma, (2019) An Internet of Things Approach for Environmental Quality Management and Laboratory Activity Support, in 2019 14th Iberian Conference on Information Systems and Technologies (cisti), New York: Ieee,.

Marques G. and R. Pitarma, (2019) Air Quality through Automated Mobile Sensing and Wireless Sensor Networks for Enhanced Living Environments, v 2019 14th Iberian Conference on Information Systems and Technologies (cisti), New York: Ieee.

Mulero R. et al, (2017) An AAL system based on IoT Technologies and Linked Open Data for elderly monitoring in Smart Cities. New York: Ieee, , pp. 93–98.

Mulero R. et al. (2018), „An IoT-Aware Approach for Elderly-Friendly Cities“, IEEE Access, Vol. 6, pp. 7941–7957

Mulero R., V. Urosevic, A. Almeida, and C. Tatsiopoulos, (2018) Towards ambient assisted cities using linked data and data analysis, J. Ambient Intell. Humaniz. Comput., Vol. 9, no. 5, pp. 1573–1591

Mydlarz, C., Salamon, J., and Bello, J. P. (2017). The implementation of low-cost urban acoustic monitoring devices. Applied Acoustics, 117, 207–218.

Nijkamp, J.E., Mobach, M.P. (2020). Developing healthy cities with urban facility management. Facilities, vol.38, no.11/12, pp. 819-833.

Nef T. et al. (2017), Evaluation of Three State- of- the- Art Classifiers for Recognition of Activities of Daily Living from Smart Home Ambient Data, Sensors, Vol. 15, no. 5, pp. 11725–11740

Pahor, M., Skerlavaj, M., and Dimovski, V. (2008). Evidence for the network perspective on organizational learning. Journal of the American Society for Information Science and Technology, 59(12), 1985–1994

Peterlin, J., Dimovski, V., Mesko, M., and Roblek, V. (2021). Cultivating Management Education Based on the Awareness of Students' Multiple Intelligences. Sage Open, 11(1), 2158244020988277.

Peterlin, J., Dimovski, V., Tvaronaviciene, M., Grah, B., and Kaklauskas, A. (2018). The Strategic Process of Developing Social Aspects of Sustainability Through the Vision Reflection in Business Education. Technological and Economic Development of Economy, 24(4), 1718–1736.

Roblek, V., Mesko, M., Dimovski, V., and Peterlin, J. (2019). Smart technologies as social innovation and complex social issues of the Z generation. Kybernetes, 48(1), 91–107.

Roy P., C. Chowdhury, D. Ghosh, and S. Bandyopadhyay, (2019) JUIndoorLoc: A Ubiquitous Framework for Smartphone-Based Indoor Localization Subject to Context and Device Heterogeneity, Wirel. Pers. Commun., Vol. 106, no. 2, pp. 739–762

Schulz A., O. Arnold, and L. Kirsch, (2014) Smart Districts in an Ageing Society. New York: Ieee, pp. 1–4.

Shakoor S., Z. Kaleem, M. I. Baig, O. Chughtai, T. Q. Duong, and L. D. Nguyen, (2019) Role of UAVs in Public Safety Communications: Energy Efficiency Perspective, IEEE Access, Vol. 7, pp. 140665–140679

Skerlavaj, M., Stemberger, M. I., Skrinjar, R., and Dimovski, V. (2007). Organizational learning culture—The missing link between business process change and organizational performance. International Journal of Production Economics, 106(2), 346–367.

Suryanegara M., D. A. Prasety, F. Andriyanto, and N. Hayati, (2019) 5-Step Framework for Measuring the Quality of Experience (QoE) of Internet of Things (IoT) Services, IEEE Access, Vol. 7, pp. 175779–175792,

Szander, N., Ros-McDonnell, L. and Bogataj, M. 2018. „A Feasible Nurse Routing Plan for the Elderly: Quality and Spatial Trade-Offs“. Pp. 201–9 in Closing the Gap Between Practice and Research in Industrial Engineering, uredil E. Viles, M. Ormazabal, in A. Lleo. Cham: Springer International Publishing.

Szander, N., Ros-McDonnell, L., and Bogataj, M. (2017). Spatial dispersion of housing units as an important factor influencing long-term care operational costs. *Urbani Izziv-Urban Challenge*, 28(1), 147–156.

Torre I. and I. Celik, (2016) A Model for Adaptive Accessibility of Everyday Objects in Smart Cities. New York: Ieee, 176–181.

Usenik, J. and Bogataj, M. (2005) A fuzzy set approach for a location-inventory model. Transportation planning and technology, 28(6), 447-464.

Vegesna, A., Tran, M., Angelaccio, M., and Arcona, S. (2017). Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review. Telemedicine and E-Health, 23(1), 3–17.

Wlodarczak P., J. Soar, and M. Ally (2016), Context Aware Computing for Ambient Assisted Living, in Inclusive Smart Cities and Digital Health, Vol. 9677, C. K. Chang, L. Chiari, Y. Cao, H. Jin, M. Mokhtari, in H. Aloulou, Ur. Cham: Springer International Publishing Ag, pp. 321–331.

Bozic, K. and Dimovski, V. (2019). Business intelligence and analytics for value creation: The role of absorptive capacity. International Journal of Information Management, 46, 93–103.

Hernaus, T., Skerlavaj, M., and Dimovski, V. (2008). Relationship between organisational learning and organisational performance: The case of Croatia. Transformations in Business and Economics, 7(2), 32–48.

Zagorsek, H., Dimovski, V., and Skerlavaj, M. (2009). Transactional and transformational leadership impacts on organizational learning. Journal of East European Management Studies, 14(2), 144–165.