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Available Technologies for Mass Transport Modes in Smart Cities

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Abstract

Mass transit is essential to the movement of people in urban cities. A city that intends to be smart needs to integrate mass transit systems—buses, tramways, subways, and trains—with Intelligent Transportation Systems (ITS) to improve urban transport services. The objective of this study is to analyze the relation of mass transportation modes in smart cities with the technology applied to them. Thus, a literature review was conducted to identify scientific publications about the theme, and the textual mechanic analysis using Iramuteq software 4.0.3 was applied. This study cites the technologies incorporated into mass transportation modes presented in literature and describes the current scenario of smart and sustainable mobility for public transportation.

Keywords

Mass Transit, Smart Cities, Technologies, Review

1. Introduction

Smart Cities seek to apply sustainable technology to mitigate climate change and improve the resilience of social dynamics in a global, creative, and intelligent way in urban areas (Hatuka et al., 2018). Urban factors and indicators contribute to mapping and planning in Smart Cities (Giffinger et al., 2007) by the intensive use of technological resources (Cugurullo, 2018).

There is not a single definition of Smart Cities, and there are different standards adopted for their assessments (Ramaprasad et al., 2017). There is a variety of indicators for Smart Cities (Chourabi et al., 2012), and new indicators, such as water and public transport management, that can be included in addition to the traditional ones (Kylili & Fokaides, 2015). The concept of Smart City is emerging and uses different reflections, constituting a fertile field for research in the most different areas of knowledge (Janik et al., 2020).

A Smart City is a community formed by a flexible service-oriented computing infrastructure based on open standards and with innovative services that serve its population (Toru & Isbiste, 2000; Yovanof & Hazapis, 2009; Lee et al., 2014). Since 1990 the theme Smart Cities has been associated with an ideal city, and from 2000 to 2020 its conceptual structure was consolidated in a pioneering manner (Giffinger et al., 2007).

Currently, Smart Cities are exploring alternatives to respond to the growth of urbanization and its consequences and challenges, also serving as a trend to facilitate technology as a basis for smart cities (Alavi et al., 2018). There are also strategic approaches of technology providers in Smart Cities with a focus on complex systems and their digital infrastructures, on Big Data Analytics, on optimization and digital automation of services, on oriented hardware and software, on connectivity and the Internet of Things (IoT), on Cloud Computing and on the Internet of Service (IoS), on Strategy Consulting, and on service outsourcing (Buuse & Kolke, 2019).

One of the main challenges in Smart Cities is the transportation systems. The current private transport system based on cars is inefficient and unsustainable, while mass transportation systems provide constant travel, combining different modes and transport services (Utriainem & Pollanen, 2018).

Therefore, it is important to determine how mass transportation systems have been incorporated into technology to meet the demand in smart cities based on the literature that studies the subject. The researched literature addresses studies for autonomous and sustainable public transport in the Smart Cities environment, specifically in the use of smart and less polluting technologies for mass transportation. And several authors discuss smart technologies applied to mass transit (Mouratidis & Serrano, 2021; Kim et al., 2021; Piao et al., 2020) and their energy efficiency and sustainability (Correa et al., 2019; Savchuk & Nahorny, 2020).

The importance of this article is the discussion of how subways, tramways, and specially buses technologies can improve smart and sustainable mobility in smart cities, as well as to investigate these technologies availability in the future to mitigate the challenges of dealing with thousands of public transportation data. It is important to highlight that one limitation of this article is that the major analyzed contexts of this work were smart cities from high technology poles in Europe and America, which can bias the determination of these technologies availability to all smart cities, regardless to their economic social evolution and their investments on Research and Development (R&D).

The article explores a novelty in academic research that is the grouping of smart and sustainable technologies for mass transport modes in smart cities at the beginning of the 21st Century. It brings to the discussion the analysis of these trends for public transport in smart cities.

In this context, this article aims to analyze the modes of mass transportation in smart cities through smart and sustainable technologies described in the literature. This work seeks to contribute to the theoretical discussion on smart and sustainable mobility in smart cities from existing technologies in mass transport. The methodology applied is the literature review mechanized via textual analysis using Iramuteq software version 4.0.3.

This paper is organized as follows: the introduction section gives a brief account of the environment between smart cities, public transport and mass transport modes, relating them to the objectives, trends and results of the research; in the smart cities section, an argument for the review is sought, in the methodology section, possible smart and sustainable technologies for mass transport modes are raised; the results and discussion section consolidates the results of the literature review and mechanized textual analysis; and the conclusion section defines which technologies and transport modes are trends in the last twenty years for smart cities according to applied research.

2. Smart Cities

Smart City is the process of the virtual reconstruction of a city through its connections and spaces using new technologies (Droege, 1997). They are intelligent environments implanted through information and communication technologies, creating intelligent spaces in urban areas (Steventon & Wright, 2006). They aim is to make the infrastructure components and essential services of a city more intelligent, interconnected, and efficient (Hollands, 2008; Washburn et al., 2010; Anthopoulos & Fitsilis, 2010). The city is monitored by the authorities through an intelligent network, and, on the other hand, users can access services regardless of where they are (Jang e Suh, 2010). It connects new information and communication technologies to the modernization of cities' infrastructure (Janik et al., 2020).

Cities can be classified in four levels, according to the technologies that are applied and adopted in their urban structure (Leem & Kim, 2013; Hall et al., 2000; Dirks & Keelin, 2020). The first level is called Digital City, in which there is a service-oriented infrastructure that connects individuals to the smart devices of a city. The main feature of this city is the use of a flexible computational structure with open systems provided by the industry and with innovative technological standards (Leem & Kim, 2013; Yovanof & Hazapis, 2009). The second level is called Intelligent City, which focuses on data that is identified and connected by Artificial Intelligence and Learning Machine (Komminos, 2006). The third level is known as Smart City which uses smart indicators with the objective of sustainability in urban areas (Hollands, 2008; Petrolo et al., 2014; Washburn et al., 2010; Anthopoulos & Fitsilis, 2010), and the fourth classification is called Ubiquitous City, which conceptualizes that all public services are comprehensive, ubiquitous, and accessible to all technological infrastructures of the smart city concept (Jang & Suh, 2010).

Smart Cities factors and indicators can be similar over time in different cities and stages with socioeconomic, economic, and environmental, contributing to the evolution of these smart characteristics (Giffinger et al., 2007; Meijeringa et al., 2014; Clarke, 2013; Artieda, 2017; ISO 37122, 2017; Monzon, 2015). Smart

Cities are formed by categories such as technology, management and organization, political context, governance, people and communities, economy, construction of infrastructure and environment (Alawadhi et al., 2012). They are composed of pillars such as the social, the management, the economics, the legal aspects, the technology, and sustainability (Sujata et al., 2016), and indicators as Smart Economy, Smart Governance, Smart Living, Smart Environment and Smart Mobility (Giffinger et al., 2007; Papa et al., 2015). A Smart City develops human, social, transport, and modern communication areas, infrastructure investment, leading to sustainable economic growth and high quality of life (Caragliu & Bo, 2018).

3. Methodology

The qualitative approach methodology was developed in two steps:

The first one is the data collecting, in which a literature review based on planning, selection, extraction and execution (Okoli & Schabram, 2010; Stechemesser & Guenther, 2012) was performed on Science Direct and IEEE Xplore academic reference bases. The objective of this stage was to collect publications that related their papers' keywords to mass transit modes, energy sources and technologies research objects in the past 20 years.

The procedures for collecting this data can be described as follows:

1) The first criterion was that the articles should be empirical studies published in scientific journals about the mass transit modes, energy sources and technologies.

2) The abstracts were exported from the academic databases using electronic spreadsheets to better collect and manage bibliographic references.

3) A total of 818 abstracts catalogued between 2009 and 2021 were found in the IEEE Xplore, and 917 of them in Science Direct academic reference base. There were 100 papers duplicated in the two bases, and they were excluded from one of them, so that the result could be a list of unique papers.

4) The second exclusion criterion was the non-association of mass transit theme to smart cities literature or the fact that the original research had not been developed in a smart city environment.

5) From the 818 found in IEEE Explore academic database, 798 were excluded, resulting in 20 articles to be analyzed. From Science Direct academic database, 901 works were excluded out of 917, which resulted in 16 selected articles. This, the number of articles in the analyzed sample was 36.

Once the sample was established, the following procedures were taken:

1) Using the bibliometric indicators used on the index fields taken from the research base, a descriptive analysis was developed rostering the following items: author, abstract, keywords, citation numbers, patent numbers, publication topics and references.

2) After that, a qualitative analysis of each article content was done, aiming at the identification of the themes that were in the introduction, objective, instruments, and main results.

After these procedures, the articles which mentioned smart and sustainable technologies, mass transit transportation, the authorship and the year of publication related to the bibliographical results were listed.

The result of this step can be seen in Table 1.

Table 1. Literature on smart and sustainable technologies for mass transport in smart cities.

Mass Transit	Authors	Theme
E-buses	Shaikh et al. (2020)	Applications/ Tracking
	Soni & Upadhyay (2016)	Green power source
	Wang et al. (2013)	Wind energy efficiency
	Zhang et al. (2017)	Electric power/ route optimization
	Zhang (2017)	Energy efficiency
	Utsumi et al. (2013); Liberto et al. (2018); Meishner et al. (2017)	Energy and sustainable efficiency
	Piazza et al. (2019)	Smart Energy and Smart Mobility
	Gabbar et al. (2020)	Clean power source
	Ferguson et al. (2019)	Transition to electrification
	Kadam et al. (2018)	Smart bus
	Muthuselvil et al. (2019)	Intelligent Bus System based on IoT
	Mouratidis & Serrano (2021)	Autonomous buses
BEBs	Correa et al. (2019)	Energy transition between Diesel, Hybrid, Electric; Fuel cell.
	Lv et al. (2021)	Deep learning
	Tesar et al. (2020)	Energy efficiency and batteries
	Lv et al. (2021)	Energy and sustainable efficiency
	Ke et al. (2020)	Smart grid, residual energy, wind energy
	Mahmoud et al. (2016)	Alternative energy sources (Hybrid, fuel cell, and battery)
	Majumder et al. (2019)	Additional charge for photovoltaic charging (Clean Energy Sources)
	He et al. (2020)	Energy and sustainable efficiency by smart charging
	Ma et al. (2021)	Energy efficiency and Smart Card
Bioethanol bus	Velásquez et al. (2011)	Energy efficiency
Tramways	Belhassen et al. (2019)	Algorithms and techniques for facial and object detection by application
	Popescu & Popescu (2013)	Smart grid and new sources (renewable)
	Vernard et al. (2009)	Real-time computing device for the visually impaired
	Chen et al. (2019)	Deep Leaning
	Retscher & Bekenova (2020)	Wi-fi and sensors
	Akcin et al. (2016)	Energy and sustainable efficiency
	Savchuk & Nahorny (2020)	Sustainable and ecological technologies
Subway	Kim et al. (2021)	Big Data and Artificial intelligence
	Piao et al. (2020)	Machine Learning and Virtual Reality
	Kang et al. (2020)	Energy efficiency by algorithms
	Loy-Benitez et al. (2020)	Sensors for air quality in stations
	Jafari et al. (2021)	Regenerative Breaking Energy (RBE)

Source: Authors, from the literature.

The second step was the application of the mechanized textual analysis technique. There was a mechanized application via textual analysis by the Iramuteq software version 4.0.3 on the data collected from step one. Iramuteq is a free and open-source software, which allows statistical analysis on textual corpus and on tables in individuals/words, developed by Pierre Ratinaud (Lahlou, 2012; Marchand & Ratinaud, 2012) and licensed by the GNU GPL (v2). It is anchored in the R software (Software R, 2021) and in the Python language (Python, 2021). The purpose of the program is to provide more accurate support for text analysis, making it possible to present statistics, Reinert's Method, similarities, classifications, and word clouds.

After Iramuteq's analysis, the data presented on **Table 1** was separated into two groups. The first group is comprised by 11 articles (out of 36 articles in **Table 1**) which focus on research in "smart technologies" and are disposed on **Table 2**. The second group is constituted by 25 articles out of 36, which focus on research in "sustainable technologies" and are presented on **Table 3**.

Table 2. Smart technologies for mass transport in smart cities.

Technologies	Mass Transit	Authors
Smart	E-Buses	Shaikh et al. (2020)
		Kadam et al. (2018)
		Muthuselvil et al. (2019)
	BEBs	Mouratidis & Serrano (2021)
		Lv et al. (2021)
	Tramways	Belhassen et al. (2019)
		Vernard et al. (2009)
		Chen et al. (2019)
		Retscher & Bekenova (2020)
	Subway	Kim et al. (2021)
		Piao et al. (2020)
		Mahmoud et al. (2016)
		Majumder et al. (2019)
		He et al. (2020)
		Ma et al. (2021)
	Tramways	Popescu & Popescu (2013)
		Akcin et al. (2016)
		Savchuk & Nahorny (2020)
	Subway	Kang et al. (2020)
		Loy-Benitez et al. (2020)
		Jafari et al. (2021)

Source: Author, from the literature.

Table 3. Sustainable technologies for mass transport in smart cities.

Technologies	Mass Transit	Authors
Sustainable	E-Buses	Soni & Upadhyay (2016)
		Wang et al. (2013)
		Zhang et al. (2017)
		Zhang (2017)
		Utsumi et al. (2013)
		Liberto et al. (2018)
		Meishner et al. (2017)
		Piazza et al. (2019)
		Gabbar et al. (2020)
		Ferguson et al. (2019)
	Bioethanol bus	Velásquez et al. (2011)
	BEBs	Correa et al. (2019)
		Tesar et al. (2020)
		Lv et al. (2021)
		Ke et al. (2020)
		Mahmoud et al. (2016)
		Majumder et al. (2019)
		He et al. (2020)
		Ma et al. (2021)
	Tramways	Popescu & Popescu (2013)
		Akcin et al. (2016)
		Savchuk & Nahorny (2020)
	Subway	Kang et al. (2020)
		Loy-Benitez et al. (2020)
		Jafari et al. (2021)

Source: Author, from the literature.

4. Results and Discussion

4.1. Modes of Mass Urban Transit in Smart Cities

Mass urban transport proposes models of transport modes within the environment of the fourth industrial revolution, or the technologies of Industry 4.0, such as Battery Electric Buses (BEBs), E-buses, Smart Tramways, Smart Subway, and Smart Trains. It places this technology to improve communication, intelligent information, and environmental sustainability to enhance actions in smart cities mitigating the challenges of smart mobility.

Two aspects can be explored in the literature on smart cities and mass transit and their smart and sustainable technologies related to the abundance or scarcity of research on buses, tramways, subway, and trains:

1) There is some research on smart cities environment, but they do not cite

the expression "smart cities" in their publications, even if they are included in urban or metropolitan technological environment for trams (Vernard et al., 2009; Chen et al., 2019; Retscher & Bekenova, 2020, Akcin et al., 2016; Savchuk & Nahorny, 2020) or subways (Kim et al., 2021; Piao et al., 2020, Kang et al., 2020, Loy-Benitez et al., 2020; Jafari et al., 2021).

2) There are studies developed in the environment of smart cities that mention the expression "smart cities" in their publications related to urban or metropolitan technological environment for BEBs (Mouratidis & Serrano, 2021; Correa et al., 2019), Majumder et al., 2019), tramways (Vernard et al., 2009; Chen et al., 2019; Retscher & Bekenova, 2020; Akcin et al., 2016; Savchuk & Nahorny, 2020) and subways (Kim et al., 2021; Loy-Benitez et al., 2020; Jafari et al., 2021). It means that the connection between Smart Cities and mass transit can be a field to be explored in the coming years.

3) There was not enough research on technologies for urban and metropolitan trains to be included in this review. This outcome suggests the need to increase the researched academic bases to look for these keywords to be explored through specific future literature reviews.

4.2. Textual Analysis of Smart Technologies in Mass Transport Modes in Smart Cities

Table 2 presents the literature on smart technologies as a database for textual analyses. The first relation presented by Iramuteq is the word count and the structure of texts on smart technologies. The results from this analysis were:

- Number of texts: 11;
- Number of occurrences: 2131;
- Number of forms: 697;
- Hapax number (expressions used a single time): 442 (19.80% occurrences - 60.55% forms);
- Average occurrences/text: 193.73.

The Zipf diagram, **Figure 1**, is the graphic representation of the frequency of a term with its ranking (rangs). That is, the ranking organizes the position of those which are most cited. As it can be seen in the report and in the graph, only one term is constantly repeated, while the vast majority—442 terms—is mentioned only once. It indicates a wealth of vocabulary on the part of the IEEE Xplore and Science Direct academic reference bases. The higher the single frequency of a term, the more complex the text.

Among the most used expressions in the 11 articles collected with the theme of smart technologies, there were the mentions "bus" (53 occurrences), "model" (20 occurrences) and "passenger" (19 quotes), the words "system" and "time" had nine mentions each. The word "autonomous" appeared 8 times; "operation", "transport", and "urban" had 7 mentions each, while "detection", "service", and "smart" had 6 mentions. It is important to mention that the terms "algorithm", "android", "environment", "information", "prediction", "technology", "traffic", "tramway", and "vehicle" had 5 mentions each.

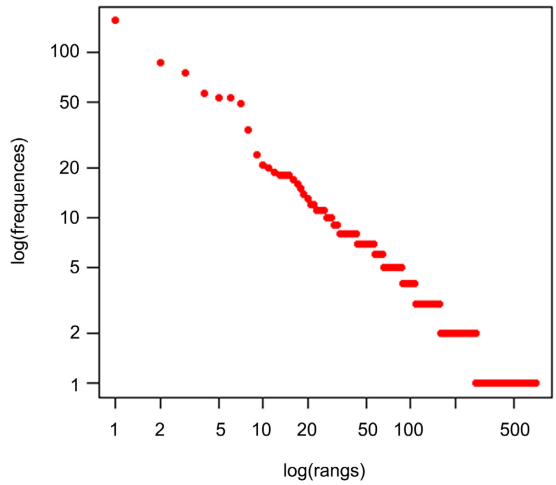

Figure 1. Zipf diagram on smart technologies. Source: Iramuteq (2021).

In these cases, the relationship between technologies from industry 4.0 and industry 5.0 stands out, especially because of the constant connection with the theme of smart cities and public transportation. The term "bus" is constantly used as associated with the system of simulator technologies for time-targeted routes and for data transmission in the urban transport system of a smart city. For example, authors such as Shaikh et al. (2020) explore applications/ tracking for smart technologies in their research, Kadam et al. (2018) explore smart bus and Muthuselvil et al. (2019) explore intelligent bus system based on IoT. Mouratidis and Serrano (2021) explore research on autonomous buses and Lv et al. (2021) explore deep learning research, regardless of Industry 4.0 or Industry 5.0 technologies applied, as these authors focus their efforts on smart mass transit to a smart city.

Figure 2 presents the result of Reinert's Method application, for mapping the vocabulary according to the vicinity of terms to the quadrants in relation to texts on smart technologies.

When building the word cloud from the counting performed by Iramuteq, the following formation can be seen: **Figure 3**

In addition to the mentions already highlighted in this analysis, it is also possible to verify the words related to transport systems such as "travel", "public", "application", "service", and "smart", as well as terms more associated with public transportation, such as "passenger", and "system", frequently used in the collected scientific articles. The connection of these words results in the so-called "similarity analysis", which represents the similarity between all texts selected for the corpus. The closer they are, the more similar the expressions (**Figure 4**).

It is possible to verify that the bus transport mode is often associated with terms which are most of the time linked to the transportation system management actions for the use of intelligent technologies, focused on current issues of use of autonomous technologies, such as "operation", "application", "detection", "method", "prediction", and "development". In general, it is possible to observe that the terms are (deeply) associated to the construction of intelligent environment context for the transport system, focused on meeting the needs of urban mobility for the population.

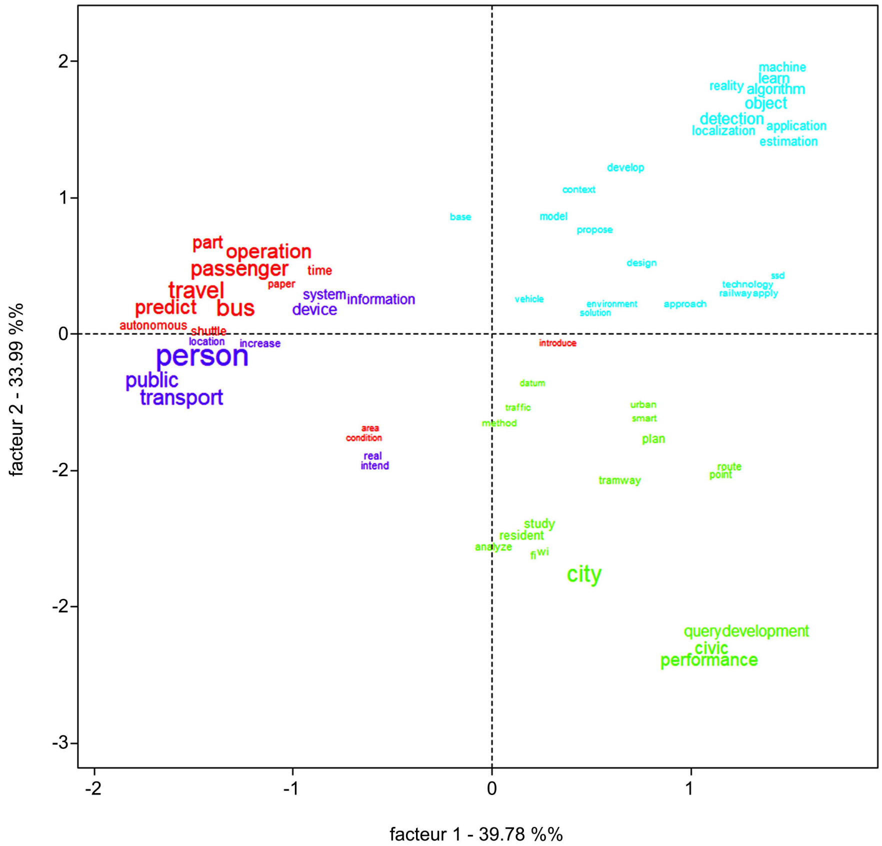

Figure 2. Reinert's Method graph of selected texts on smart technologies. Source: Iramuteq (2021).

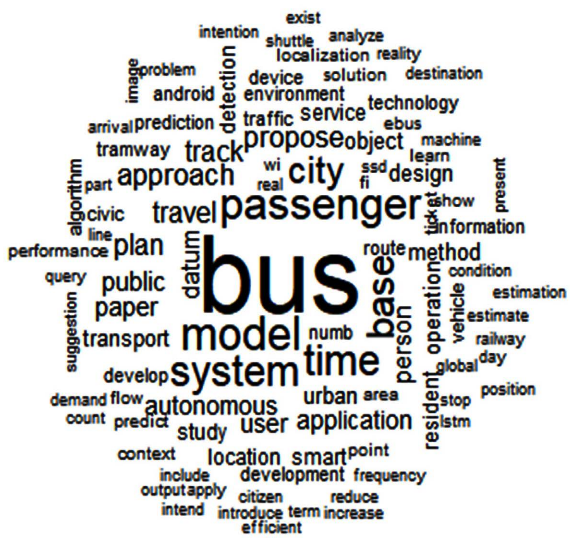

Figure 3. Word cloud of selected texts about smart technologies. Source: Iramuteq (2021).

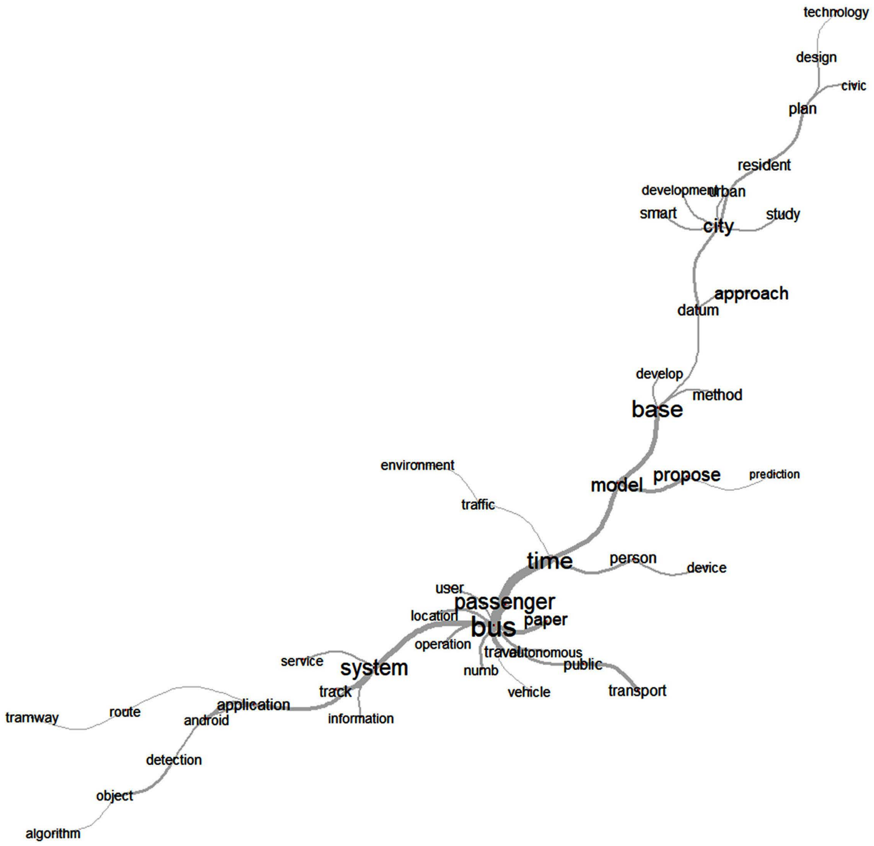

Figure 4. Word tree of texts about smart technologies. Source: Iramuteq (2021).

Finally, it's possible to say that the size of the abstracts texts—five paragraphs on average—do not influence the depth of the vocabulary and the relationship with the methodology of the research, as the quality is in its technological results for the mass transportation system.

4.3. Textual Analysis of Sustainable Technologies in Mass Transport Modes in Smart Cities

Table 3 presents the literature on sustainable technologies as a database for textual analyses, whose results are disposed on **Figure 5**.

The first list presented by Iramuteq is the word count and structure of texts on sustainable technologies. For this analysis, we obtained:

- Number of texts: 25;
- Number of occurrences: 4138;
- Number of forms: 1003;
- Hapax number (expressions used a single time): 504 (12.18% occurrences - 50.25% forms);
- Average occurrences/ text: 165.52.

Among the most used terms in the 25 articles collected on the theme of sustainable technologies, there are the words "bus" (75 mentions), "energy" (49 mentions), "charge" (46 mentions), "model" (34 mentions), "system" (33 mentions), "city" and "electric" (30 mentions each), "battery" (22 mentions) and

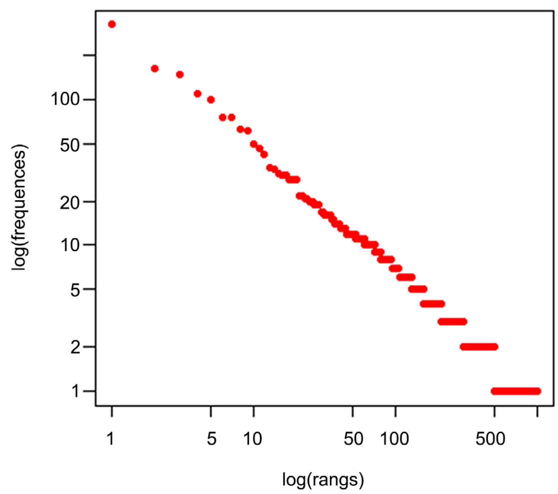

Figure 5. Zipf diagram on sustainable technologies. Source: Iramuteq (2021).

"power" (20 mentions). The terms "operation" and "vehicle" had 19 mentions, "public" and "result" had 17 mentions, while "cost", and "technology" were mentioned 14 times. It is important to emphasize that "consumption", "electricity", "electrification", "present" and "urban" had 12 mentions each.

In these cases, the stranded-out relation happens among technologies in the search for cleaner energy sources for the modes of public transportation, especially because of the constant connection with the model themes of energy system and public transport. The word "bus" is constantly associated with the technologies of electric, electrified and battery power systems in public transportation in a smart city. For example, authors such as Soni and Upadhyay (2016) explore research on green power source, Wang et al. (2013) detail the use of wind energy efficiency, while Zhang et al. (2017) apply electric power for route optimization for E-buses with electrical systems. Correa et al. (2019) explore energy transition among diesel, hybrid, electric; fuel cell in their research, Tesar et al. (2020) detail energy efficiency and batteries, while Lv et al. (2021) apply energy and sustainable efficiency to Battery Electric Bus (BEBS), regardless of the technologies they used (electric chargers or rechargers or battery systems coupled to vehicles).

Popescu and Popescu (2013) explore smart grid and new sources (renewable) in their research, Akcin et al. (2016) explore energy and sustainable efficiency, Kang et al. (2020) explore energy efficiency by algorithms, and Loy-Benitez et al. (2020) explore sensors for air quality in stations and seek to improve the performance of electrified mass transport as a whole and not just in the tramway or subway transportation mode.

All the mentioned authors focus their efforts on creating less polluting and more efficient technologies for the metro-railway transport system.

Figure 6 presents the result of Reinert's Method application, for mapping the vocabulary according to the vicinity of terms to the quadrants in relation to texts on sustainable technologies.

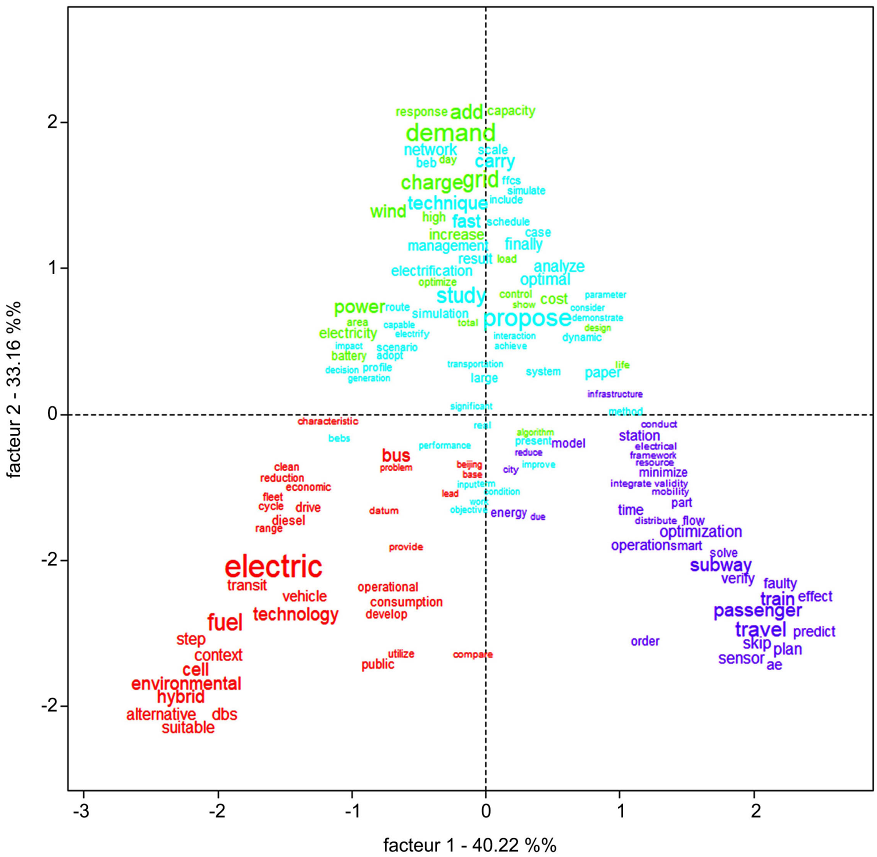

Figure 6. Reinert's Method graph of selected texts on sustainable technologies. Source: Iramuteq (2021).

When building the word cloud from the counting performed by Iramuteq, the following formation can be seen (Figure 7) (Figure 8).

In addition to the mentions already highlighted in this analysis, it is also possible to verify the expressions related to transport systems such as "electrification", "diesel", "transport", "sensor" and "optimization", as well as words usually associated public transportation, such as "bus", "charge" and "energy". The connection of these words results in the so-called "similarity analysis", which represents the similarity between all texts selected for the corpus. The closer they are, the more similar the expressions.

It is possible to verify that the bus transport mode is often associated with words that are most of the times associated with transport system management actions for the use of sustainable technologies focused on current issues in the use of alternative energy sources such as "simulation", "electrification", "compare", "reduce", "minimize", "optimization". In general, it is possible to observe that the terms are (deeply) associated to the construction of intelligent environment context for the transport system, focused on meeting the needs of urban mobility for the population to mitigate the effects of pollution by transport in urban and metropolitan areas. Finally, it's possible to say that the size of the abstracts texts—five paragraphs on average—do not influence the depth of the vocabulary and the relationship with the methodology of the research, as the quality is in its technological results for the mass transportation system.

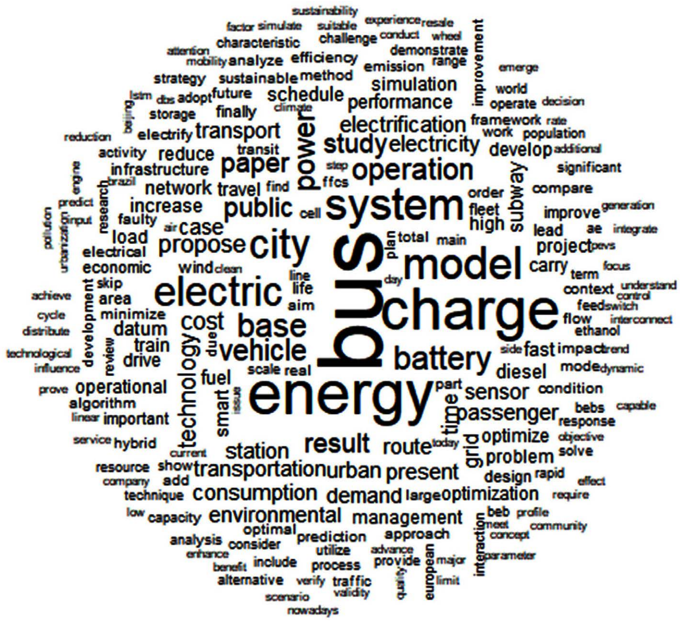

Figure 7. Word cloud of selected texts about sustainable technologies. Source: Iramuteq (2021).

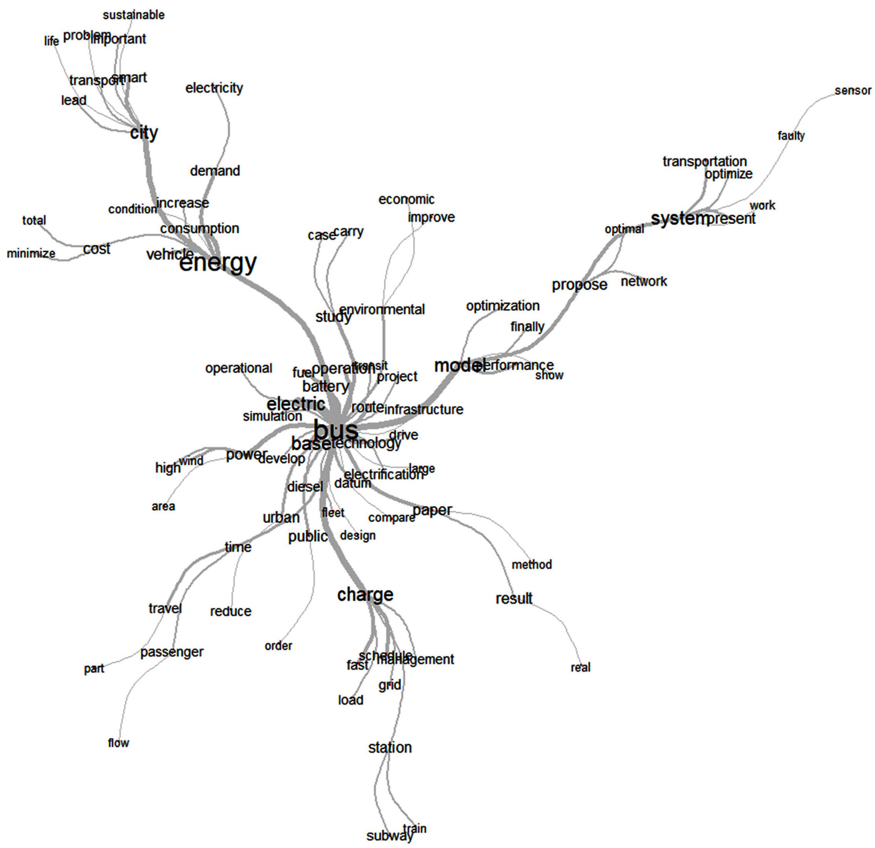

Figure 8. Word tree of texts about sustainable technologies. Source: Iramuteq (2021).

5. Final Remarks

The objective of this study was reached by answering that the smart technologies used in the urban mass transport system in smart cities are technologies that are mentioned in the literature review as technologies to improve the autonomous performance of the bus transport mode. In addition, these technologies focus on capturing vehicle and user data for information processing and decision-making for the creation of intelligent services in public transport, forming smart and sustainable mobility for the mass transport system. Sustainable technologies in the literature review point to the use of a battery-powered bus system in buses and a smart charging grid within the smart city. In this way, there is greater efficiency being generated in operations with less polluting fuels when compared to the consumption of fossil fuels in public transportation. Other alternatives such as full cell and hybrid fuel source are also mentioned and recommended. Electrified modes of transport such as tramways and subway have the public transport system as a systemic set with high connectivity between roads, stations, vehicles and intelligent information systems and rechargeable energy sources. The use of renewable energy sources in the means of transportation raises concerns about sustainable mobility for smart cities through research evidenced by the literature on mass transport modes and their technologies. This concentration of smart and less polluting technologies characterizes the urban mass transport system between the period 2009 to 2020 in smart cities. It also brings the contribution to future research of its link with the fourth industrial revolution, Industry 4.0, and Industry 5.0 in the public transportation. The limitation of this study is the uniform application of these technologies evidenced by the literature review and textual analysis in smart cities that have different economic and social profiles in each country. Thus, any technology mentioned here roughly changes the scenario and the result, as it is influenced by the local need of its citizens and by the amount of investment made in public transportation by each smart city, specifically in this technological grouping.

For future work, it would be interesting to study multiple cases in groups of different smart cities by continents or countries, investigating how their mass transport system is composed and how their smart and sustainable technologies are concentrated in each mode of mass transport such as buses, subways, tramways, or trains.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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