Industry 4.0 and Smart cities: State of the art

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Abstract

Smart city is one of the most exiting industries of 21st century. The aim of this paper is to investigate the state of development of smart cities and its application. As a research method, the state-of-the-art research papers were analyzed. The key results presented in this paper show the impact of industry 4.0 on smart cities with technological advancements and its future developments. It was found that application of artificial intelligence within smart city industry will continue to grow in future as one of the main industry fields. The main objective in the future will be solving social challenges, enhance citizen wellbeing and specific endogenous problems. Therefore, the focus will be more on people, governance and policy rather than technology and economy.

Keywords: Smart city; Industry 4.0; Innovation

1. Introduction

In this research application of Industry 4.0 technologies in smart cities is explored. A comprehensive state of the art literature is analyzed. After going through those materials, this paper presents the implementation of industry 4.0 with smart cities, various ways of implementation as well as advantages and disadvantages. Difference between this paper and others found online is focus on connection of Industry 4.0 and Smart cities rather than exploring both topics separately. Smart city researchers and arrangement creators frequently allude to the brilliant city - along these lines inferring a homogenous methodology [1].

This underplays the significance of neighborhood conditions in molding one of a kind smart city imaginaries and on-the-ground ventures. As of not long ago, a smart city alluded to a glorified, mechanically determined, to a great extent mechanized city that was created starting from the top related to enormous information and innovation organizations. As the brilliant urban communities advertise has kept on advancing, urban areas are supporting what we call Smart Cities 2.0 techniques that put individuals first and stresses innovation as an instrument to utilize dominatingly in administration of residents [2].

This paper will also review the importance of industry 4.0 in smart city development. The technological advancement is moving quickly, empowering fabricating organizations with new opportunities for advanced changes to offer items and administrations to present and new markets at serious expenses. Such present-day advancements are called Industry 4.0 [3]. The term Industry 4.0 starts from the German "Industrie 4.0", created in 2011 in Germany as a German Federal Government activity to fortify the intensity of the German assembling industry [4].

Other chapters will include the integration of industry 4.0 into smart cities which will talk about how industry 4.0 helped to expand smart cities and rapidly increase development curve of the smart city [5]. Future of smart cities will also have its own chapter and few perspectives based on different papers reviewed will be covered. It will try to answer the question what will happen in future, will industry 4.0 continue to be integral part of smart cities, will development of smart cities continue to rise in such a rapid rate etc. All those questions will be answered based on review of latest research papers written on this topic [6].

Table 1 presents some of the references covering this topic.

Table 1. References on Smart city and Industry 4.0 topics

Scope	Result	Year	Reference
Smart city development	Describes the smart city	2016	[1],[2],[4],[7],[8], [11],[12],[14]
Industry 4.0	Industry 4.0 introduction	2016	[13],[15], [16],[18]
Smart city architecture	Describes smart city development	2017	[24], [25], [31], [32],[41]
Smart city 2.0	Describes future of smart cities	2019	[40], [42], [43],[45],[50], [52]
Industry 4.0 in smart city	Describes integration of industry 4.0 in smart city	2018	[24],[27],[28],[30],[26]
Smart city development	Describes the smart city	2018	[3],[5],[9],[10]
Industry 4.0	Industry 4.0 introduction	2018	[17],[19],[20],[23],[33],[35],[36]
Smart city 2.0	Describes new features of smart city 2.0	2019	[53],[54],[56],[59],[37]
Industry 4.0 features	Describes new features of industry 4.0	2019	[61], [62], [64]
Architecture of Smart city 2.0	Describes newest architecture of smart city 2.0	2020	[46], [47], [48], [49]

2. Industry 4.0 and Smart cities

The standard purpose behind the ascent of the smart cities initiative is making an acceptable model for urban networks and shield individual fulfillment of their inhabitants. The subject of the smart cities is not considered uniquely to be a specialized control, however extraordinary monetary, helpful or lawful viewpoints must be included [11]. In the possibility of Industry 4.0, the Internet of Things (IoT) can be used for the improvement of assumed splendid things. Sub-fragments of these things are outfitted with their own insight. Included knowledge is used both during the amassing of a thing, up to diligent checking of the things lifecycle (keen systems) [12]. Interconnection of these structures can be depended upon transport structures. Associating information from process-based Industry 4.0 with smart vehicle systems of the city could make useful improvement of society [13].

Germany is first to introduce Industry 4.0. After Germany, the term was spreaded all around the world. The name Industry 4.0 alludes to the forward mechanical insurgency, with the initial three coming to fruition through automation, power, and IT [14]. The forward mechanical insurgency, and henceforth the 4.0, will come about by means of the Web of Things and the Internet of administrations getting incorporated with the fabrication. Be that as it may, all the advantages of past upsets in industry came to fruition sometime later, though with the forward insurgency we get an opportunity to proactively control the manner in which it changes our reality [15].
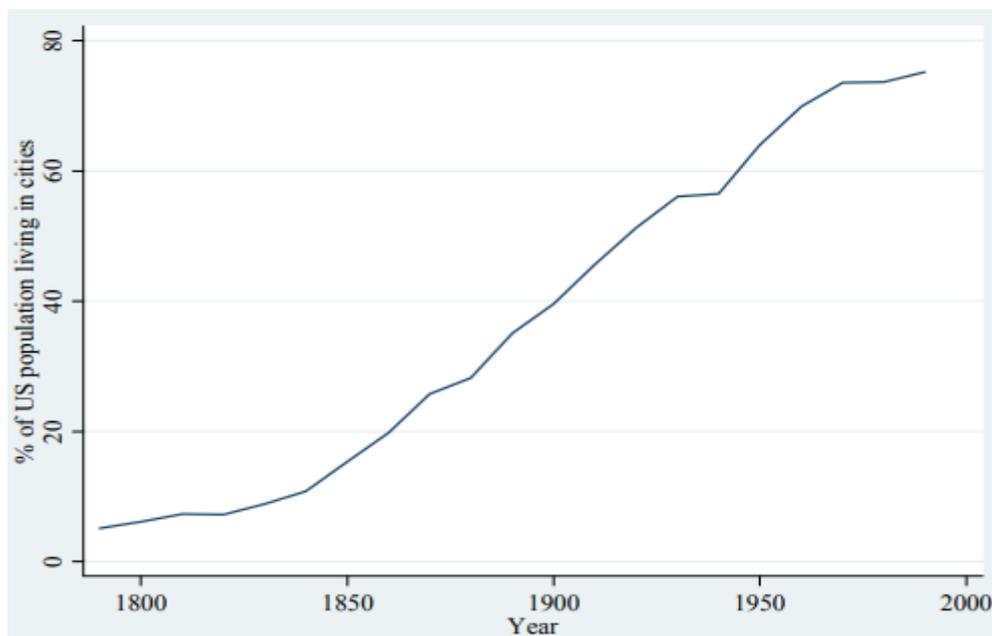

Figure 1. Percent of people in USA living in urban area [67]

The vision of Industry 4.0 is that later on, modern organizations will construct worldwide networks to associate their hardware, plants, and warehousing offices as digital physical frameworks, which will interface and control one another by sharing data that triggers activities [16]. These digital physical frameworks will cover the state of processing plants, savvy machines, brilliant offices, and flexible chains. This will achieve upgrades in the modern procedures inside assembling in general, through building, material utilization, flexible chains, and item lifecycle [17]. At the focal point of this vision will be the processing plant, which will adjust the way creation is performed [18]. It won't be simply digital physical systems such as keen hardware that will be smart; the items being gathered will likewise have insight of the goal that can be recognized all through the assembling procedure [19].

The vision held is that the installed frameworks are coordinated with the vertical business forms, (deals, coordination, and funds, among others) and related IT frameworks. They will empower savvy manufacturing plants to control the start to finish the board of the whole assembling process from flexible affixes through to administrations and lifecycles. Notwithstanding, in the Industry 4.0 framework, these elements will go about as one. Keen production lines don't relate just to tremendous organizations, undoubtedly, they are perfect for little and medium-sized endeavors as a result of the adaptability that they give [22]. For instance, authority over the level assembling process and brilliant items empowers better dynamic and dynamic procedure control, as in the ability and adaptability to take into account plan changes or to change creation to address a client's inclination in the items plan. Moreover, this dynamic procedure control empowers little parcel sizes, which are still beneficial and oblige singular custom requests. These dynamic businesses and designing procedures empower better approaches for making inventive plans of action [23].

Table 2. Industry 4.0 technologies and e-learning capacities

Industry 4.0 technologies	E-learning	
	Yes	No
Production and scheduling software	41%	28%
Digital visualization	30%	8%
Production for safe human-machine interaction	12%	6%
Product exchange	25%	20%
Programming devices	12%	4%
Product managment system	14%	5%

3. Integration of Industry 4.0 in Smart cities

Today the greater part of total population lives in urban territories (Fig. 1). Worldwide urbanization shows expanding advancement. In spite of the way that world's surface is involved by just 2% of urban territories, urban settlements amass over half of population and expend up to 75% of regular assets [24]. Subsequently, the issue of "brilliant" urban turn of events, recovering arrangements of population development and relocation issues, environmental change, instruction and wellbeing, reasonable lodging and urban life change affected by data and correspondence advancements (ICTs, computerized advances) with regards to fourth mechanical upset have pulled in expanding consideration in the last decade and the issues of "smart" urban advancement are talked about in various configurations [25]. Present day investigations of future (or "shrewd") urban areas have a few multidisciplinary contents. Among them - issues with respect to practical social, natural and financial improvement of urban areas and issues with respect to complex city biological systems the board in order to access fundamental assets like lodging, clean air, clean water for whole occupants. The Maintainable Cities Index incorporates these parts of the "smart city" idea. For instance, the 5-top of worldwide urban areas are Zurich, Singapore, Stockholm, Vienna and London [26]. Moscow positions 57. in general.

Enthusiasm of the scientists concentrated on the "computerized city" during the 1990s, as the significance of "advanced" had been expanded when the EU government upheld the program "European Digital City" in 1996- 1999. During this period, enthusiasm of scientists, government officials and financial specialists was centered around advancement of various data administrations for residents giving collaboration of urban occupants furthermore, region by utilizing new innovations. Motivation behind this program was to choose 15 urban areas and help them in figuring it out the potential being developed and advanced strategy execution which would change lives of occupants, organizations, laborers and business people. In 2008, IBM CEO Samuel J. Palmisano, noticed that "our planet is getting more astute" on the grounds that the world has been progressively outfitted with "computerized" instruments (sensors are being brought into all biological systems). The world is turning out to be increasingly interconnected and progressively smart (developing new

processing forces, models and supercomputers) [27]. Dynamic improvement of the "brilliant" culture started toward the finish of the principal decade of 2000's when "shrewd" prefix started showing up in varieties word articulations like "shrewd turn of events", "keen development", "brilliant guideline", "shrewd city", "keen plant", "smart home" [28].

4. Smart city development based on Industry 4.0

In the idea of "smart city" adequate significance was recently given to giving residents open administrations. Rising new ICT age is causing all components of city and its foundation (economy, transport, instruction, clinical consideration, open request, and the board) to become "smarter" [8]. From one perspective, advancement of Internet of things, coordinated frameworks and their worldwide systems administration (for instance, keen vehicle arrange that is utilized to manage blockage), of digital physical frameworks to make new open doors for building "keen city" and progress to "smart economy" in view of Industry 4.0 [29].

Improvement of Industry 4.0 will take care of certain issues of assets and vitality proficiency, urban creation, segment changes in megacities. Industry 4.0 makes creation innocuous to urban condition. Creation gets scholarly, advanced and coordinated not just at the level of a straightforward processing plant. Advanced innovations make conditions for level coordination which is going past the "keen industrial facility" and advance computerized chains of significant worth creation at nearby, provincial, national and worldwide levels [9]. Then again, the advancement of "smart urban areas" as an objective of urban, modern, monetary, social, natural arrangement advances new industrialization and digitization of current economy. "Shrewd urban communities" are making progressively alluring conditions for living, work, training, human capital, pulling in money related assets for business improvement [30].

The expression "smart urban communities" is applied not exclusively to urban communities; it deals with today more generally. "Smart urban communities" can be viewed as agglomerations or "Uber centers" of the present advanced economy [31]. It is fundamental to think about turn of events of Industry 4.0 as formation of "savvy urban communities" and agglomerations just as different items like "brilliant processing plant", "keen home", "brilliant road", "shrewd grounds" and others which are mutually molding computerized economy at the degree of the city, locale, nation. New computerized innovations are not just changing straightforward creation into esteem chains dependent on the Internet of Things and digital physical frameworks and making new types of cooperation underway frameworks - yet in addition making new connections between makers, providers and clients [33].

Industry 4.0 is making mechanical and innovative reason for rising "shrewd urban communities" whose advancement and incorporation turns into an indispensable component of economy digitalization. A shrewd city additionally needs a huge measure of information stockpiling, which can be accomplished through state, an electrically tunable metasurface [34]. This innovation could influence a scope of fields, (for example, imaging, correspondence, encryption, and information storage). The reaction of guaranteed shrewd city to unsure information is noteworthy, prompting the topic of how to measure the heartiness of a shrewd city. An evaluation structure must mull over different attributes, including shrewd city methodology and the interests all things considered, (for example, evaluators, ICT foundations, legitimate and administrative strategies, administrations, plans of action, and supportability). The goals of such a system are to look at the qualities of various keen urban areas to distinguish new difficulties, evaluate benefits, and assess execution.

In shrewd urban communities, effective security support is a significant necessity of VANETs. One thought is the manner by which to make sure about them by structuring arrangements that lessen the probability of system assaults or even how to lessen the impact a fruitful assault could have on them. A keen city needs lightweight, adaptable confirmation systems that secure drivers from interior and outside assailants. The IEEE 1609.2 v2 standard determines a lot of security administrations (for example, testament expert) for supporting vehicular interchanges. Open key infrastructure-based (PKI-based) answers for check vehicle security probably won't lead to an adaptable arrangement. Cross-affirmation ought to be characterized when nations or urban areas have numerous root declaration specialists. The power answerable for trouble making identification ought to be joined into the PKI framework. Structuring and sending keen urban areas needs specialists from different fields, counting financial aspects, humanism, building, ICT, and arrangement and guideline [37]. Different systems depicting the engineering of brilliant urban communities have been proposed by both industry and scholarly sources. One of the most generally adjusted and embraced models is the reference model proposed by the U.S. National Institute of Standards and Technology. Keen urban areas are perplexing frameworks, frequently called "frameworks of frameworks", including individuals, foundation, and procedure segments. Generally shrewd urban community models comprise of six segments: government, economy, portability, conditions, living, and individuals [38]. Different methodologies and techniques have

been proposed to assess keen urban communities from numerous points of view, including a urban Internet of Things (IoT) framework for brilliant urban areas, manageability, worldwide city execution, future urban situations, urban seriousness, and strength.
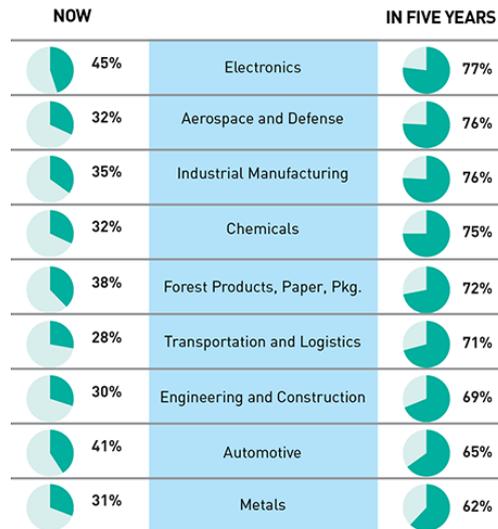

Figure 2. Adoption of Industry 4.0 by sector [68]

5. Future of Smart city

Advancement of "smart city" basics was joined by development this idea content [40]. Prior, the smart city idea concentrated more on advancement of smart considered as a complex environment whose administration required arrangement of consistent access to essential assets without harm to nature [41]. In this manner, with the developing effect of new "advanced" innovations applied on the procedure of urbanization, specialists concentrated on "digitalization" and improvement of different data administrations [42]. At long last, advancement of Industry 4.0 innovations (Web of things, distributed computing, digital physical frameworks, large information and others) has made it conceivable to make entire urbanization process more brilliant: urban arranging and development ("keen home"), creation and business ("smart processing plant" and "keen economy"), the board ("brilliant guideline") - what's more, to make conditions for improvement and aggregation of social and human capital ("shrewd population") [10]. In this way, Industry 4.0 advances are creating today an in a general sense new foundation of the "smart city", making new open doors for settling specific issues with respect to assets and vitality effectiveness, urban creation association, segment changes in present day megacities. Thus, "smart city" improvement turns into a type of new industrialization of the advanced economy [43].

The solid enthusiasm by metropolitan governments worldwide in smart city communities originates from their capacity to improve their residents' nature of life. Here, we depicted a portion of the fundamental ideas of savvy urban communities, distinguishing difficulties and future research chances to empower enormous scope arrangement of savvy urban areas [44]. Engineers, modelers, and originators ought to presently center around parts of IoT the board, information to the executives, savvy city appraisal, VANET security, and inexhaustible innovations, (for example, sun-oriented power) [45]. We trust to see shrewd city engineers, planners, and creators give adaptable, financially savvy answers for address them later on [46].
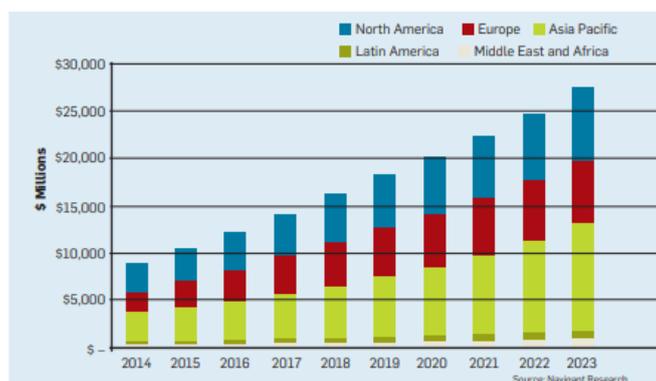

Figure 3. Smart city infrastructure investment by industry (2014-2023) [69]

6. Research on the world of Smart cities

There is plenty of new research activities around the world. It begun with the IBM Smarter Planet Initiative1, rapidly followed by the MIT City Science program. What's more, Trinity's Smart and Sustainable Cities initiative3 , all tending to fundamental parts of this dynamic field. In any case, the majority of these activities center around a shut arrangement of subjects, which prompts a somewhat restricted, nearness driven view on the space [47]. So as to empower a really comprehensive interdisciplinary and future evidence approach, it is imperative to address the space of brilliant urban areas on a more elevated level of reflection [48]. I.e. to empower the recently presented Ideal Smart City [49]. We have to make the logical underpinnings for future Web of Cities Infrastructures (IoCI). To guarantee this, a far-reaching set of systems, models, and instruments for plan, improvement, the executives, and advancement of next generation shrewd city applications is required. Such work requirements is to follow a standards as a way to tackle the great difficulties of future shrewd urban areas through close reconciliation of analysts and partners from various spaces - to make an open, comprehensive, and interdisciplinary research stage [50].

6.1. Metodology

The subsequent significant focal point of the IoCI will be on formulating an exhaustive procedure to help partners in structuring, creating, and advancing reusable and viable keen city applications. We will put together our exploration with respect to MADCAT [5], an iterative programming designing approach for cloud applications with an express spotlight on curiosity detectability, reuse, and improved partner correspondence. Expanding on endeavors of intently coordinating partners from various areas into the way toward making shrewd city applications, we will make an all-encompassing approach for building shrewd city applications that unequivocally empowers the plan and improvement of reusable and freely viable application parts in close participation with master partners [51]. The philosophy will permit for a capacity arranged methodology for catching and bundling required usefulness in particular, reusable units that can be shared and coordinated in numerous applications [52]. Such units characterize their normal condition by means of plainly determined interfaces, taking into account the consistent mix of demonstrating furthermore, recreation situations, just as genuine foundation, giving an unmistakable deliberation between the framework being worked on and its execution surroundings, for example, testing, organizing, and creation, each with varying degrees of reproduced condition resources [53].

To dependably work and oversee future brilliant city applications, the third mainstay of the IoCI is a far-reaching toolset that will permit administrators to consistently convey and execute complex applications in an autonomic, repeatable, and perceptible way. So as to do as such, we will separate these devices in three unique layers that expand upon one another. On the most minimal layer (framework layer), building the establishment, one needs to oversee and screen the accessible shrewd city foundation, comprising of independent servers, cloud situations, edge foundations [54]. In the framework layer we need an exhaustive toolset that permits administrators to uncover, oversee, and screen the basic framework in a uniform and extensible way. In light of the framework layer, one needs to give a runtime layer to shrewd city applications that permits and supports the accompanying key perspectives. To begin with, the runtime layer needs to help versatile application arrangement thinking about the focusing on framework, anticipated number of clients and required information volume. Second, the runtime layer needs to give a runtime domain to executing savvy city applications that permits to consistently scale applications across different foundations [56]. Third, to manage the extent of information positions, tremendous information volume the runtime layer needs to give productive and versatile information on the board, comprising of information intercession, change, handling and capacity. At last, since different keen city applications can be executed at the same time, the runtime layer needs to give both versatile information and application confinement levels, that permit various inhabitants to work at the same time without meddling each other. The last layer (mix layer of our toolset is then answerable for incorporating novel keen city application advancement techniques, models, and reproductions [57]. The reconciliation layer bolsters diverse application improvement and organization stages (i.e. reenactment, testing, creation, and rollout), which gives administrators and engineers diverse application runtime situations by getting to either mimicked or genuine frameworks. Furthermore, the reconciliation layer opens interfaces to recover information that is gathered during the execution of uses also, the administration of the basic foundation, in request to i.e. feed recreations, extricate utilization designs, or create models [58].

6.2. Modeling

Modeling face difficulties because of an absence of accessible real-world framework to make and confirm applications in wording of usefulness, non-utilitarian properties, or administrative necessities [59]. Current

arrangements either depend for little scope testbeds or exclusive, hand crafted reenactments to copy true situations (e.g., Anylogic5) [60]. Be that as it may, such arrangements are a long way from perfect, as changes in realworld conditions should be physically repeated in lab testbeds or recreations, and the relocation of uses from test framework to certifiable arrangements must be painstakingly arranged and physically completed for each new application variant [61]. Moreover, brilliant city applications being worked on in part depend on information that is now accessible in the physical condition, and subsequently would profit from utilizing certifiable information rather than recreations if conceivable. Inside the IoCI, this test will be tended to by grasping the requirement for displaying and reproducing portions of an application's condition, just as incorporating genuine world information from the physical condition at various stages during its lifecycle at the center of our examination endeavors [62].

7.   Conclusions

Introduction of Industry 4.0 brought a lot of possibilities for many industries to profit. The one of it that profited the most are Smart cities. Industry 4.0 integrated into smart cities and is helping them to become more efficient using technologies like cloud and IoT. One of the most significant reactions for the past three mechanical insurgencies and their related approaches is the inability to understand the most problems that are begging to be addressed that keep on confronting present day social orders. These incorporate environmental change, ceaseless maladies, and imbalance. With the progress to Industry 4.0, arrangement producers should think its worldwide effect on present and potential social issues through the social components of new advancements. Society on the loose should profit by such modern change, since purchaser and maker are to a great extent associated also, both can take an interest in the creation and utilization process. Smart cities will surely profit from integration of Industry 4.0. Industry 4.0 focuses on energy efficiency and reliability and it is absolutely essential in modern Smart City. Artificial intelligence from industry 4.0 will help in enhancing urban transportation, water management etc. But all in all, most important aspect which industry 4.0 adds into smart cities is sustainability [63]. Ability of controlling all parts of the process will make it easier to conserve raw materials and energy. All in all, we can conclude that Industry 4.0 will definitely radically improve smart cities development and implementation. One of the reasons why smart city industry is booming is because there is a big rise of people living in urban areas and they all present the possible residents (As shown in figure 1) [64]. As this paper discussed in chapter 4 the development of internet of things as well as all digital technologies made it easier and more flexible to develop new ways of improving smart cities through digitalization and most importantly artificial intelligence [42]. Artificial intelligence development will continue to rise in future as one of the main industry fields, and with its rise smart city industry will also profit. The future of smart cities as discussed in chapter 5 is all about focusing on people, governance and policy rather than technology and economy. That is the policy of "Smart city 2.0" [65]. The main objectives of "Smart city 2.0" are to migrate and solve social challenges, enhance citizen wellbeing and enhance specific endogenous problems. The approach of new smart cities is decentralized rather than centralized [66].

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