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Smart Cities, a Modern Application of 3D Printing, Sensors and Artificial Intelligence

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Abstract: Smart cities nowadays have lots of different forms and techniques. After the development of smart cities in many countries and regions, intelligent development in many places has encountered certain bottlenecks. As a result, this report has investigated more methods that can encourage further development of smart cities. For 3D printing, this article discussed the availability of 3D printing machines in improving the process of chip-making and investigated the future aspect of 3D printing houses in urban areas. For sensors, the discussion of the application of sensors in IoT of smart cities and intelligent bus services. For artificial intelligence, this article explains the types of AI, Industrial 4.0, the application of AI and engineer learning, a new way of industrial use of smart cities, the application of artificial intelligence robots for service humans, and the 6G combined with AI in some fields. With the thought of a higher development level of smart cities, they can provide better governance capability.

Keywords: Smart Cities, 3D printing, Sensors, Artificial Intelligence.

1. Introduction

As the world started to pay more attention to the techniques that can make the whole human being live a better life, smart cities have become a topic that is highly anticipated by the public. Many large companies and countries are developing smart cities by combining different skills such as IoT, engineer learning, sensors, artificial intelligence and so on. Such as in China, many parking lots use sensors and AI to deal with the number of cars parked in the lot, and pass the Information to the other drivers, to achieve clear control of the traffic volume. The same technique is also used in controlling the number of tourists in a scenic spot. Another instance is in Singapore, where most of the public sports yards and gyms can make an order through your mobile phone, and the residents can easily deal with daily problems such as health care, and the doctors can use the application provided by the government, to know about the situation of the patients more accurately.

This report will pay more attention to the application of smart cities through 3D printing, sensors, and artificial intelligence.

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2. 3D-printing

3D printing is more and more likely to be an important form of future technology with roles such as construction or industrial use. For example, in Singapore, the government is going to provide more 3D printing residences for residents [1]. In other developed countries, 3D printing is widely used in medical research and applications.

In China, 3D printing has become a favored skill in manufacturing some micro devices such as chips and so on. Compared with traditional methods of manufacturing chips through steppers, 3D printing will help to reduce errors during the process. However, the current situation is that most of the chips nowadays used on smartphones or personal computers are fabricated on steppers with high accuracy and precision. So, 3D printing chips are likely to be a technique with an endless future in smart cities.

Firstly, with current steppers controlled by Holland ASML Holding N.V., the minimum distance of the circuit grid has reached 5mm (about 0.2 in) between 7mm (about 0.28 in). This determines the final capability and ability to deal with the data. 3D printing skills are not likely to provide higher accuracy on the other processes like drying glue, exposure, or something else. 3D printing can indeed provide better construction on gluing, which is the original step of the whole process of producing a chip.

Secondly, compared with the applicator now used during the step of gluing, 3D printing has the following advantages. Currently, the key points of the coating technology of applicator machines are the flatness of the coating, which means the uniformity of the coating layer on the surface of the chip. In the past, due to the limitation of controlling system and the structure of the applicators, the flatness was hard to control, which lead to the bad quality of chips used in electronic devices. 3D printing may help provide a different point of view for gluing. 3D printing can use unique skills which are controlled by computers and artificial intelligence, to improve flatness. On the other side, the traditional manufacturing process is mainly through human beings; after handing in the artificial intelligence and 3D printing, the machine can achieve automation and higher efficiency.

StickNFinds is a micro-device that can use phones to detect objects [2]. Further, StickNFinds can provide more ways of thinking for smart cities. Not likely to change the current principles of maintaining smart cities but try to provide more convenient details for smart cities. For instance, Apple Inc. published their new functions of finding other electrical devices through your iPhone or iPad and so on. Apple is the pioneer in the application of this technique. For smart cities, the function can help to manage the cities with higher efficiency. Such as if the community needs to collect information about the residents, or search for a resident imminently, this function may be quite useful. Through the chips manufactured with the help of a 3D printing gluing machine.

The first 3D printing building was first shown to the world in 2016 in Dubai, which is a milestone in applying 3D printing in construction industry [3]. According to the project published by the Singapore government, they are going to provide more 3D printing houses for residents. Cheap and environmentally friendly are not the only benefits of 3D printing houses but also have many other advantages. According to the research on the future development of 3D printing houses in Singapore, the benefits brought by this skill are becoming more and more welcome and more developed. For instance, during the process of manufacturing the residences, smart city devices can easily combine those residential houses together [4]. Thus, the government will manage these houses more clearly, and the people can get better living feelings. 3D printing houses are also facing problems. Low productivity, high demand for houses, and so on.

Without large-scale production, the spread of 3D printing houses will be difficult. In recent years, countries including the USA, China, Japan, and so on, are trying to put large input into producing 3D printing houses and are about to put them into practice in some urban areas.

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In the future, 3D printing can continue to empower the construction of smart cities. More advanced housing and central control systems, more precise cameras or other electronic components. Traditional industrial manufacturing structures, which can better provide manufacturing convenience for urban smart management. promoting the intelligent construction of future human society.

3. Sensors

3.1. The role of sensing in smart cities (SC):

Innovative solutions are urgently needed in a constantly rising world population that drives resource consumption and causes climate change. This is especially true for urban areas, which are responsible for the main consumption and pollution, increasing the need for creating smarter infrastructures to explore greener and more energy-efficient urban construction. The solutions include most urban dynamics, as illustrated in Figure 1 [5].

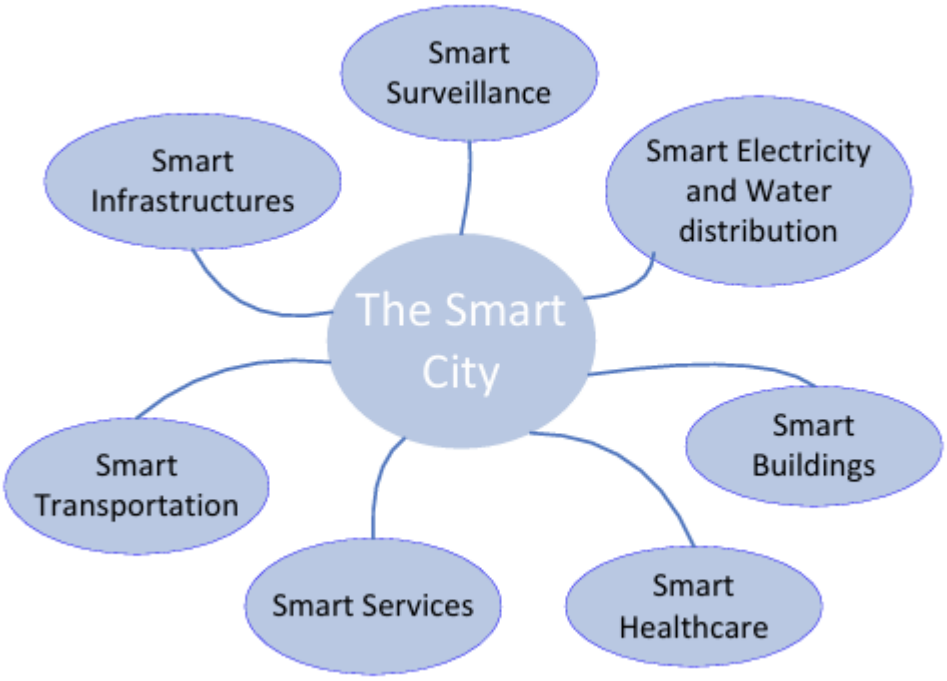

Figure 1: Sensing in Smart Cities [5].

To achieve Smart Cities, we need to allow people and things to be connected regardless of the time, space, service and network [6]. Which is the definition of Internet of Things (IoT). The relationship between SC and IoT, is like the procedure and result as shown in figure 2. We can allocate the need towards technology from SC to IoT. Achieve technology to need from the other side.

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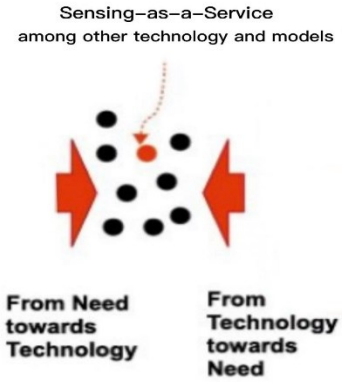

Figure 2: Relationship among sensing as a service model, Smart Cities and Internet of Things[7].

Sensing is the core of IoT and SC, which can monitor the condition, adjust the behavior, predict the result and act on their own automatically [5]. Using sensors to monitor the air condition and noise level, to predict the vehicle amount, to analyze the waste fill level and water quality, provides awareness of more efficient consumption of the resource, a more harmonious and comfortable living environment, and a more scientific and intelligent city system.

3.2. PortoLivingLab: An IoT-Based Sensing Platform for Smart Cities

ProtoLivingLab, an urban-scale, multisource sensing infrastructure that leverages IoT to sense the four phenomena of city-scale: weather, environment, public transport and people flow deployed in the city of Proto, Portugal [8].

It builds on three monitoring platforms. SenseMyCity (SMC) is a mobile crowdsensing tool that can use sensors to gather data by a smartphone application [8] [9].UrbanSense is a set of low-cost sensing stations aiming at monitoring and analyzing various urban parameters (such as air condition, noise level, resource consumption) [8] [10]. BusNet is a smart public transportation network composed of over 600 public vehicles equipped with onboard units (OBUs) [8] [11]. The procedure of processing data includes Sensing, Data Collection and finally Storage, Processing and Sharing.

The raw data collected from sensors is stored in per platform databases which helps organize the data. The way of structuring data is similar which allows to combine data from various spatial and temporal easier. For data services procedure, the backend server plays an important role in helping analyze, filter and prepare. Allowing to share data is efficient and powerful, here uses Publish-Subscribe Middleware for real-time data streams and RESTful API for historical data. After that, the processed data made available to the public, which is achieved by standard interfaces, can help third-party developers innovate more urban applications. Considering data security and privacy, the crowdsensing data remains anonymized and aggregated, showing average values instead of individual information.

3.2.1. SMC

As a mobile crowdsensing research tool, SMC can gather data from participants' mobile phones, with a sensing probe which is a smart application with input from devices and users, SMC enables sensing the physical world using embedded sensors [8]. Moreover, SMC supports an efficient and secure data transmission mechanism, which can ensure data security and privacy, and the gathered data can be transmitted from Wi-Fi or cellular communications decided by users [8]. The data is integrated into a centralized backend platform to enable data processing and analysis, in figure 3.

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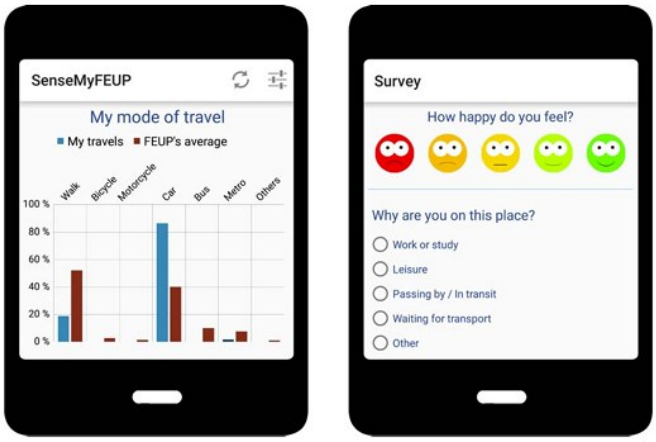

Figure 3: Example SMC user interface and mood questionnaire [8].

The SMC platform is configured for many applications. Here we pick SenseMyMood as an example. The application gathers mobility data during the users' move automatically and occasionally requires the users to evaluate their mood and action via a questionnaire [8]. It provides instantaneous location and speed, noise level, nearby Wi-Fi hotspots and other sensor data, which allows to correlate users' emotions and activities.

3.2.2. Urban sense

The platform consisting of sensors, pluviometer, Wi-Fi interfaces and processing, storage and control gathers data leveraging on static sensors to monitor the parameters related to weather and environment. The data collected by the UrbanSense is transmitted through Wi-Fi APs connected to the fiber ring, vehicular DTN (Delay Tolerant Network) and municipality Wi-Fi which are all commonly used in urban areas to the backend server for further processing [8].



Figure 4: UrbanSense DCU [8].

Through UrbanSense, a spatial and temporal characterization of climate and environment can be created. Data-based local models allow monitoring and modeling for various locations, which can be more economical and efficient compared with traditional physical weather models using high-quality and costly sensors, in Figure 4 [8].

3.2.3. BusNet

The BusNet is composed of OBUs (On-Board Unit) which contain DSRC (Dedicated Short Range Communications), GPS and Wi-Fi in vehicles, which enables collecting the mobility traces and

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quantify connections to the on-board Wi-Fi AP, it supports data forwarding by V2X communications through the RSU (Roadside Unit), DTN (Delay Tolerant Network) and Wi-Fi, in figure 5. [8]



Figure 5: BusNet platform hardware [8].

BusNet platform can gather multiple data from the vehicles, such as speed and the passenger amount. Through the Wi-Fi AP, OBU records and GPS, we can construct the origin-destination matrix of passengers, which allows us to understand the flow of passengers in different locations and help to improve the bus service by increasing or decreasing the bus volumes for some routes.

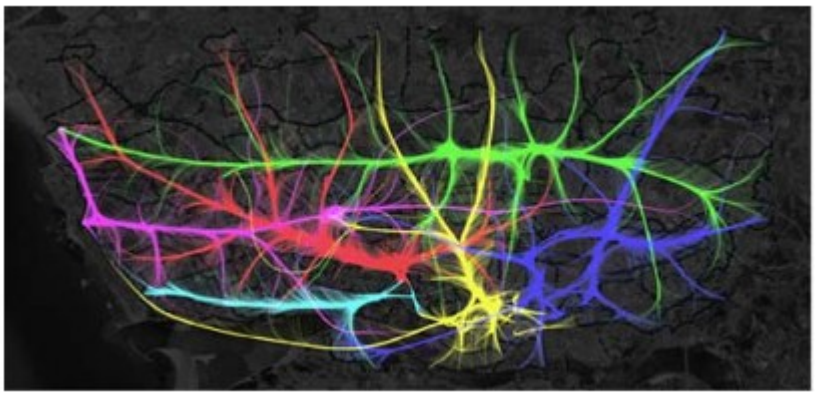

Figure 6: Passenger flows from Wi-Fi connections [8].

It also indicates the traffic situation in the city in figure 6. By computing the BusNet datasets and setting a threshold of the vehicle's speed, we can identify the lower average speed which probably means the region is more congested.

3.2.4. The prospect of sensor use in the future technology

Sensors can convert physical phenomena into electric signals, which represent a part of the interface between the physical and electrical worlds [12]. It will be widely used in this more connected and intelligent world. However, more challenges occur with the development of technology, for sensors, interoperability, energy efficiency, security and privacy, and coverage is the main four problems [13]. These KPIs provide the possible future research directions. Overall, the advancement of sensors is bright ahead, yet is fraught with challenges and difficulties.

4. Artificial intelligence

4.1. The position of artificial intelligence in smart cities

It builds up a whole new city all over the world, it provides computing power which includes cloud computing, it is general computing. Smart computing and supercomputing are high-performance

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computing power. These can be used in many fields, they can predict the weather, ecological monitoring, environment monitoring, and so on.

4.2. Application of IoT with artificial intelligence technology in smart cities

The Internet of Things (IoT) refers to items that can communicate with other platforms, record and analyze data. The integration of IoT and AI leads to enhanced intelligence, exemplified by smart cars, voice assistants, smart homes, and more. Similarly, a framework called AI Talk has been proposed, which enables efficient attachment of AI systems to existing IoT applications through a graphical user interface, facilitating the integration of AI into IoT systems without the need for scripting [14]. The incorporation of AI diversifies IoT applications and strengthens connections between smart cities.

4.3. Application of AI robots in smart cities

Service robots offer great convenience to people, as they receive information through visual, biological, and auditory signals and operate based on algorithms. For instance, robots can be used for health monitoring of the elderly by collecting information and performing corresponding actions through calculations. They can engage in conversations with humans through speech recognition systems and provide responses. Additionally, in the context of hotel room service, robots significantly save time by autonomously navigating and quickly and safely delivering meals to the guests' floors.

4.4. 6G combined with artificial intelligence in smart cities

Intelligent communication is a key enabling factor for the anticipated upcoming 6G networks. Across all 6G application scenarios, more efficient and sophisticated applications leveraging machine learning and deep learning, such as holographic projections and deeper data mining, are expected [15]. The development of edge machine learning will be a primary driving force for 6G communication [15], elevating the role and importance of AI in smart cities. More advanced algorithms can significantly expand the scope and effectiveness of AI applications, while 6G's communication speed and network coverage ensure ubiquitous high-speed internet access.

In the future, with regard to the enhancement of AI's intelligence and personalization, AI systems will become more and more intelligent and flexible, capable of providing customized services tailored to individual user needs and preferences. Regarding autonomous intelligent systems: Autonomous intelligent systems that possess self-learning, decision-making, and environmental adaptation capabilities will become more widespread. In summary, the future of AI is filled with limitless possibilities. It will profoundly change our lifestyles and work patterns, driving social progress and development.

5. Conclusion

This paper shows some of the future aspects of these three techniques that can be applied to the project of smart cities. We have concluded that 3D printing can better serve the manufacturing industry of smart cities, through methods such as simplifying the process of manufacturing the chips and provide better houses with more environmentally friendly buildings and smarter controlling systems. Sensors can more accurately catch the information, combining artificial intelligence and engineer learning, which provides managers with clearer information and easier ways of governance. The sensors with better IoT systems will provide better help for many sides, such as traffic management, industries like logistics. Robots with AI technology can help to reduce the pressure on humans and offer some assistance for management, Industrial 4.0 now is still in the situation of development, after applying

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the functions of artificial intelligence such as engineer learning and further learning, or big data model, maintaining a smart city system will embrace higher efficiency and intelligence.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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