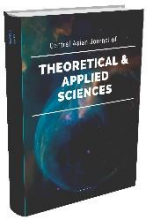

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Improving Infrastructure and Transportation Systems Using Internet of Things Based Smart City

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Annotation: *Global Smart City initiatives are made possible by the widespread adoption of the Internet of Things. In every corner of the globe, people can participate in Smart City initiatives because to the Internet of Things' centralised infrastructure. Through enhancing infrastructure and transportation systems, decreasing traffic congestion, providing waste management, conserving energy, and enhancing the quality of human life, the services are reshaping cities. In this project, we are constructing a Smart Garbage System and a pollution monitoring System utilising Arduino with Extended Ports, which allows us to integrate the smart city prototype. The key benefits of the suggested architecture and their implications for the city will be discussed in the paper. New technologies can only be created if smart city security is strengthened. Smart City, it seems, is an investigation of the IoT and its technologies and capabilities.*

Keywords: *Liquid Crystal Display, Integrated Circuit, Light Emitting Diode, Low Frequency, High Frequency, Ultra High Frequency.*

Introduction:

Physical devices, cutting-edge automobiles, cutting-edge buildings, and even essential electrical appliances that we use on a daily basis are all part of the infrastructure that makes up the Internet of Things because they are constantly connected to each other over the internet in order to accumulate and exchange data amongst themselves [1]. These Things are the most important, as they can coordinate and share information among themselves without any help from humans. The Internet of Things (IoT) has many different applications in many different fields, such as home automation, mobile healthcare, manufacturing automation, assistance for the aged, medical aids, automobiles, smart grids and intelligent energy control, traffic management, and many others [2]. Lighting, traffic management, intercity connections, energy consumption, and pollution control are just some of the many tasks that may be accomplished in a "smart city," thanks to the widespread use of Internet of Things (IoT) devices. The primary goal of these "smart cities" can change the way we see the world [3]. In many areas, the Internet of Things is poised to become the dominant force, with far-reaching effects on everything from the most routine human activities to the most nuanced of human sentiments. Citizens are the primary beneficiaries of smart city applications and the underlying ecosystem [4].

The Internet of Things (IoT) and associated IT utilise the internet to connect disparate devices into one cohesive whole [5]. To that end, it's crucial that every accessible gadget be online. This can be accomplished through the proliferation of sensors, actuators, the cloud, data science, communication technologies, machine learning, and artificial intelligence in order to collect, analyse, and ultimately increase usage in a variety of settings [6-9].

Objective of Work

The Smart Cities Mission is an initiative with the overarching goal of fostering urban areas that prioritise human well-being by investing in essential infrastructure, creating a clean and sustainable environment, and using "Smart" Solutions. Sustainable and equitable development is emphasised [10-12]. The goal of the Smart Cities Mission is to catalyse the development of other, similar Smart Cities across the country by studying existing urban centres and creating a model that can be used elsewhere [13-15].

The Smart City initiative aims to accomplish many things.

- Modifying the city's administration for the better — Making government more accessible and affordable for its citizens, via increased reliance on online services to increase accountability and transparency, particularly through the use of mobiles to decrease the cost of services and provide services without requiring a physical presence [16].
- Enhancing the current facilities and services
- Universal access to safe and sanitary housing and water and sanitation services
- Decrease traffic, pollution, and depletion of natural resources; stimulate the local economy; increase social contact; and guarantee safety.
- Supporting several modes of transportation, including Transit Oriented Development (TOD), public transportation, and last-mile para-transport connectivity.
- Creating a unique brand for the city based on its primary industry, be it food, healthcare, education, the arts, culture, sports equipment, furniture, hosiery, textiles, dairy products, etc [17].

Motivation

The city of Nice in France set out in the Smart City sector in 2008 with the goal of using various projects to stimulate regional economic growth [18]. The plan's goal was to construct a regional economic

powerhouse by bolstering the sector through the development of enabling infrastructure and the distribution of funds [19]. Twenty thousand more jobs are planned to be made available in the next two decades. Cities want to "smarten" for a variety of reasons, not the least of which is to save money or bring in more cash [20]. These reasons range from worries about the environment to desires to improve social inclusion and attract more businesses [21]. Regardless of why people move to Smart Cities, the market for such places will continue to expand, and so will the ways in which we describe them [22].

Need for Smart City

Governments must spend a lot of money to construct a smart city [23]. Nonetheless, if implemented deliberately, it is one of the best modifications in lifestyle that can be made [24]. In smart cities, every inch of available land and resource is put to good use, and everyone shares in the bounty in the most equitable way possible [25-29]. It also seeks to improve communication between government officials and the general public on a number of different fronts. All kinds of public buildings get spruced up, from classrooms to hospitals to roadways. The system can eliminate wasteful repetition in the current system, resulting in cost savings. One must evolve one's way of life to meet the necessities of the present, as technology is progressing at a rapid pace [30].

Features

Three separate modules are proposed for this project, each with its own name.

- Smart Garbage Monitoring System
- Intelligent street Management
- Weather Monitoring System

Life enhancement; public administration and services; smart traffic; smart tourism; environmental protection; and large-scale resource management; water; power; and agricultural; were the three main application domains and their sub-domains identified [31]. The six top characteristics can be thought of as general smart city application domains, and they are: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. Giffinger and Gudrun used these and 31 other factors and 74 indicators to evaluate the smartness of cities. City administration, education, healthcare, public safety, real estate, transportation, and utilities are just some of the seven essential infrastructure components and services identified. Buildings, energy grids, natural resources, the environment, and transportation are all examples of "hard domains" in cities, where the use of ICT systems, in tandem with the required policy interventions and urban planning, is necessary to promote sustainability. When it comes to processing and integrating real-time data, information and communication technology (ICT) systems have a secondary function, or "soft domain," in these settings. Citizen access to smart services is expanded to include new opportunities in the fields of learning, creativity, and discovery [32-35]. Finally, they identified seven areas that should be considered while designing a smart city: energy and resources, mobility, housing, government, the economy, and the people who live there [36-41].

Proposed System Design

To address the aforementioned issues, the proposed system introduces a number of pieces of hardware and software for use in smart city applications in the here and now [42-45]. Since the system is automated, it is imperative that the working time solutions take into account regional specifics in a regional context including regional actors [46-51]. Users are familiar with the system since it is straightforward, and they can access information about the system's sensors and its availability at any time using a mobile device. The information gathered from the sensors about the city's infrastructure is processed in the cloud, bringing cyberspace and the Internet of Things together [52-57]. Managing street

lights, garbage, parking, and the weather are only some of the smart city's many automated systems. The ultrasonic sensor is part of the smart street light management system, and it is interfaced with an Arduino mega, which then sends the values back to the LEDs that really light up the street. Below is a block diagram of how the project is supposed to work as a whole, showing how the various sensors talk to the Arduino. ThingSpeak's open-source website is linked to the ESP8266, which provides the web interface. Two microcontrollers are used for the project as a whole [58-61]. The Arduino Uno is smaller and less powerful than the Arduino Mega. There is a handshaking protocol between these two controllers that allows them to talk to one another [62-63]. Ultrasonic sensor, GSM module, and Bluetooth sensors are connected to the Arduino Mega, while the Arduino Uno is used for the likes of DHT11, ESP8266, and MQ-135 (fig.1) [64-65].

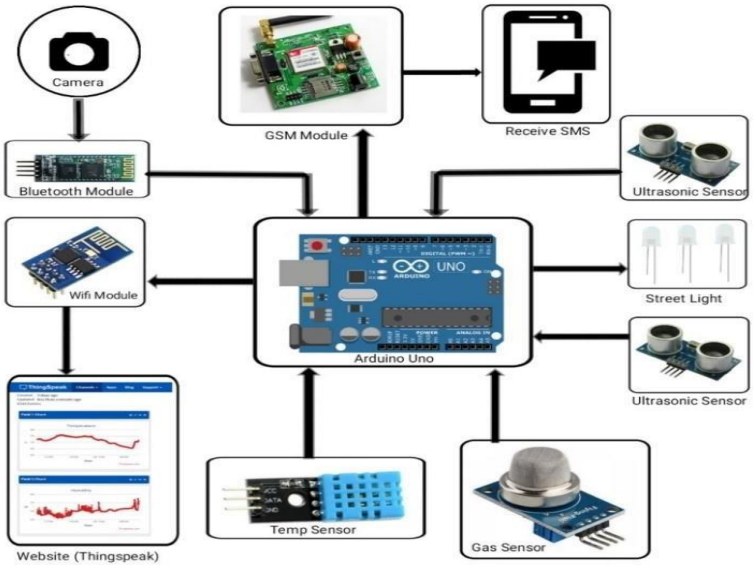

Fig 1: Proposed System Design

Smart Garbage Management System

A smart waste management system includes an ultrasonic sensor that is fastened to the top of each trash can (big container) [66-67]. The smart street light management system will use the predicted distance to determine how much garbage has been deposited in the trash can at the moment. Through the GSM module, this number will be transmitted to the appropriate authority (sim900) [68-72].

Weather Monitoring System

The DHT11 thermometer and the MQ-135 humidity and temperature sensor make up the weather monitoring system's pair of sensors. The DHT11 provides us with information on the ambient temperature and relative humidity [73-81].

Smart Street Light Management System

In the prototype, two ultrasonic sensors are installed end-to-end along a road to control the lighting system [82-83]. When this sensor determines that a vehicle is fewer than 10 centimetres away, the appropriate street light turns on. At a greater separation, the opposite streetlight will come on. This cycle is maintained in the dynamic interplay between two sensors [84].

Drawbacks of Existing System

While the future of smart cities holds great promise for improved quality of community life, they are not without their downsides.

- Insufficient public consciousness and accountability
- It is difficult and expensive to construct and keep up the necessary infrastructure.
- Requires constant power and connectivity
- Public data security concerns could pave the path for biassed treatment of people.

Think about city life before urban location; urban setting before technology. Show that it can scale up and hold up over the long haul. Exhibit adaptability over a long period of time. All new constructions should be wired and wirelessly connected, with the ability to accommodate future upgrades to the standard [85-89]. Make sure data collected by its technological systems can be made publicly available without charging a fee. Whether or not the data is made available is up to the terms of the relevant business and legal arrangement, but this shouldn't result in any unnecessary costs. Furthermore, information should be made public whenever there is no compelling business or legal reason to keep it secret. Any new construction must have IT systems that are compatible with other IT systems and with the built environment, physical infrastructures, and Smarter Cities [90-92]. The project attempts to strike a fair balance between the social, environmental, and economic costs, making the most efficient and long-term use of all available resources [93-95].

Arduino Uno

Arduino is a free and open-source hardware and software electronics development platform. Inputs such as light on a sensor, a finger on a button, or a tweet can all be read by Arduino boards and used to trigger an action such as the operation of a motor, the illumination of an LED, or the uploading of content to a website [96]. By providing signals to the board's microcontroller, it can be instructed on what to do. For this purpose, many people turn to the Arduino programming language and the Arduino Software (IDE) (fig.2).

Fig 2: Arduino UNO

Arduino has become the central processing unit (CPU) for countless projects throughout the years. Arduino was created at the Ivrea Interaction Design Institute to provide students with a simple tool for rapid prototyping who lacked experience with electronics and programming [97]. As soon as the Arduino board became popular, it began evolving to meet the changing demands of its user base, expanding its product line from basic 8-bit boards to include solutions for Internet of Things (IoT) applications, wearables, 3D printing, and embedded systems. Because all Arduino boards are free and open-source, anyone can use them and modify them to suit their own purposes [98]. The programme is also freely available to the public and is being developed with input from users all over the world [99].

ATMEGA 328P – Microcontroller

Microchip's ATMEGA328P low-power, high-performance controller. The ATMEGA328P is an 8-bit microcontroller that utilises the RISC-based AVR architecture. Since it is integrated into ARDUINO boards, it has become the de facto standard for AVR controllers. There are a lot different controllers to choose from, but the ATMEGA328P has proven to be the most popular due to its combination of

affordability and useful functionality. Due of its features, this controller is also used in the development of ARDUINO boards. The ATMEGA328 controller is utilised in the same way as any other. This can be accomplished with just a little bit of programming. Our provided code is simply run by the controller at any time. Without instructions from the programmer, the controller does nothing. As previously stated, the controller must be programmed by loading the necessary software file into the ATMEGA328P's FLASH memory. The controller then runs this code that was dumped, giving the expected result. XTAL1/XTAL2/TOSC1/TOSC2 The 8-bit, two-way I/O port labelled "Port B" includes built-in pull-up resistors (selected for each bit). High sink and source capabilities can be found in the Port B output buffers, which have symmetrical driving characteristics. If the pull-up resistors are engaged, current can be supplied to the inputs from the port B pins when they are externally pulled low. When a reset situation is present, the Port B pins are tri-stated even if the clock is not ticking.

Port C (PC5:0)

To clarify, Port C is a 7-bit bidirectional I/O port that features built-in pull-up resistors (selected for each bit). The PC5.0 output buffers include excellent sink and source capability in addition to symmetrical drive characteristics. If the pull-up resistors are engaged, the externally pulled-low pins on Port C can be used as inputs to source current. When a reset situation is present, the port C pins are tri-stated even if the clock is not ticking.

PC6/RESET

PC6 is an input pin if the RSTDISBL fuse has been set. In the absence of a preset RSTDISBL fuse, PC6 serves as a reset input. If this pin is held at a low level for longer than the minimum pulse length, a reset will occur regardless of whether or not the clock is ticking. Not all shorter pulses will trigger a reset.

Port D (PD7:0)

The 8-bit, two-way I/O port labelled "Port D" features built-in pull-up resistors (selected for each bit). There is equal amounts of sink and source capacity in the port D output buffers, indicating that their driving characteristics are balanced.

AVCC

The A/D converter, PC3:0, and ADC7:6 all receive power from the AVCC supply pin. Even if the analog-to-digital converter is not in use, the supply must be connected to VCC. If the ADC is to be used, a low-pass filter must be installed between it and VCC.

AREF

The A/D converter uses the AREF pin as its analogue reference. The Atmel ATmega328P is an advanced microcontroller that combines an 8-bit RISC CPU with an in-system self-programmable memory on a single chip, making it a versatile and cost-effective option for a wide variety of embedded control applications.

Architecture Design

Based on the AVR-enhanced RISC architecture, the ATmega 328P is a low-power, 8-bit CMOS microcontroller. The ATmega48P/88P/168P/328P delivers throughputs near 1 MIPS per MHz by executing strong instructions in a single clock cycle, giving system designers greater control over how much power is used and how quickly tasks are completed. In its core, the AVR combines a large number of instructions with 32 general-purpose data registers. Because of the direct connection between all 32 registers and the ALU, two separate registers can be accessed in a single instruction that is carried out in a single clock cycle. The resulting design is up to 10 times faster than regular CISC microcontrollers and is

more code-efficient. The AVR employs a Harvard architecture, which features dedicated memory and buses for code and data, to achieve its performance and parallelism goals. Single-level pipelining is used to carry out the instructions stored in the programme memory. The next instruction is pre-fetched from the programme memory before the current one has finished executing. Based on this idea, instructions can be carried out during each tick of the clock. The computer's ROM is a rewritable flash memory chip. Position and Authority System Interrupter General Purpose Registers, 32 Bit, 8 Bit, and So On ALU Information Highway System SRAM with 8 bits of data storage Analysis of SPI Unit Data A Guide to the Instructions Decoder A Timer With a Keep an Eye On Function Comparator, Analog Externally Erasable PROM (EEPROM) Input/Output Connections Control Line I/O Module Constantly Addressing the Audience Addressing Indirectly Two Input/Output Modules Number Counter Flash Memory Storage.

Effective address computation is made possible by allocating six of the 32 registers as three 16-bit indirect address register pointers for the data space. In addition to pointing to locations in the flash programme memory, one of these address pointers can be utilised as a table lookup address. The X-register, Y-register, and Z-register, each containing 16 bits of data, are the newly introduced functionality registers. The ALU allows for logic operations and arithmetic operations to be performed between registers or a constant and a register. The ALU can also perform operations with only a single register. The status register is updated to show the result of an arithmetic operation when it has been completed. Instructions to jump or call provide programme flow, and these instructions can be either conditional or unconditional and can address any location in the program's address space. For the most part, AVR instructions are presented as a single 16-bit word. Each location in the RAM used to store the programme points to a 16-bit or 32-bit instruction. The software installed on a device's flash memory can be broken down into two categories: the boot programme and the application programmes. Separate lock bits prevent unauthorised changes to either part while it is being written to or read from. It is imperative that the SPM instruction that writes to the application flash memory sector be located in the boot programme section. After an interrupt or a call to a subroutine, the PC is pushed onto the stack to be used as the return address.

The stack is used for a variety of purposes, including storing temporary data, storing local variables, and storing return addresses following interrupts and subroutine calls. You should know that the stack in this implementation works its way down from higher memory addresses. Invariably, the highest position on the stack can be found in the stack pointer register. The subroutine and interrupt stacks are stored in the data SRAM stack area, which is referenced by the stack pointer. The registers that manage a versatile interrupt module are located in the I/O area, and there is an extra global interrupt enabling bit in the status register. The interrupt vector table contains a unique interrupt vector for each interrupt. If an interrupt is higher in the interrupt vector than another, it will be handled first.

Power Supply

Both a USB connection and an external power supply are supported by the Arduino Uno. The board can use a voltage input of 6 to 20 volts from a separate source. However, the board may become unstable if powered by less than 7V, as the 5V pin could deliver less than 5V. If you try to use a voltage of more than 12V, the regulator could overheat and ruin your board. Seven to twelve volts is the sweet spot. Here is a rundown of the power jacks: VIN -The voltage at which an external supply is connected to the Arduino board (as opposed to 5 volts from the USB connection or other regulated power source). This is the pin where electricity can be plugged in, or accessed if power is being supplied through the jack. To power the microprocessor and the rest of the circuitry, a 5V regulated power source has been integrated. This can be supplied via USB or another regulated 5V source, or it can originate from VIN via an onboard regulator. The 3.3-volt power supply is produced by the on-board regulator. You can only use up to 50 mA of current. GND Pins that connect to the ground.

Relay

Electromechanical switches like relays use coils to perform their switching functions. The switch moves and either makes or breaks the electrical connection when a little current travels through the coil, creating a magnetic field. In most cases, a relay is used to switch an AC or DC high-voltage circuit via a low-voltage DC circuit without physically connecting the two. This means that the high voltage and low DC voltage circuits are only connected magnetically, but not electrically (fig.3).

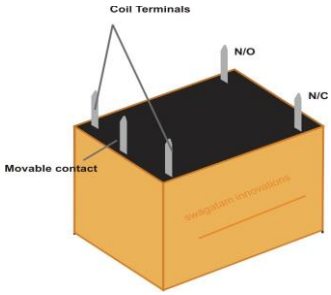

Fig. 3 : Relay

Operations of Relay

Relays are activated by passing a low current of direct current (DC) via their coils. This causes the armature to gravitate toward the NO (Normally Open) pin. The COM pin is normally connected to the NC (Normally Connected) pin when the armature has returned to its usual position after the current through the coil has been cut off. All simple relays work in the same way.

Circuit Diagram for Relay Driver

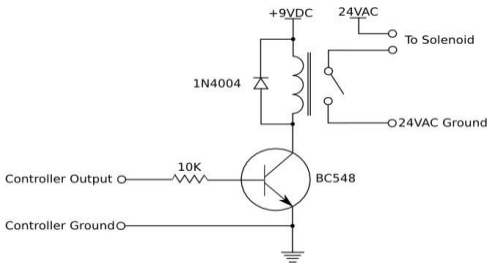

Fig. 4: Pin Diagram

Many types of screens are used by hobbyists (fig.4). One of the most cutting-edge types of screens they utilise is liquid crystal displays. You'll find it to be the simplest and most dependable output device after you've mastered the interface. The use of any debugger is also not always possible for projects based on microcontrollers. As a result, LCDs can be employed as output testers.

LCD Display

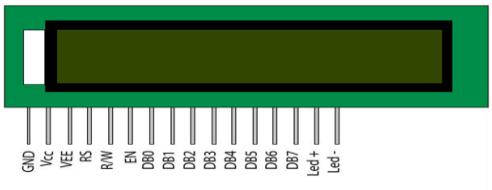

Fig. 5: LCD

Displays with liquid crystal (LCD) screens may take in both data and control signals (fig.5). The condition of the RS pin is used by the LCD module to decipher the signals. With the R/W pin set to high,

the LCD may now be used as a data reader as well. In both the reception and transmission scenarios, data is read and processed by the LCD at the falling edge of the pulse. When using an LCD, the time required to set a character or carry out a command ranges from 39 to 43 microseconds. TTL Output (for Arduino, 8051, and other microcontrollers) and RS232 Output (for direct PC interfacing) are two examples of the types of outputs that can be taken from a GSM Module's printed circuit board (PCB) (personal computer). The board will provide pins or provisions for connecting the microphone and speaker, from which +5V or other power and ground connection values can be extracted. The specifics of these clauses are module-dependent. 3.

We're using a GSM module that operates on the 900MHz band, thus we're calling it a SIM900 GSM Module. We're from India, where the 900Mhz frequency range is widely used by mobile network carriers. If you're travelling from another country, you'll need to research the mobile network band available in your region. The 850Mhz band is used by the vast majority of U.S. mobile networks (the band is either 850Mhz or 1900Mhz). Different businesses produce GSM modules, thus it's important to double-check the module's power needs. The requirements for their input power source vary widely. You should verify the power needs of your GSM module. In this guide, we will be using a gsm module that needs 12 volts to operate. We use a 12V,1A DC power supply to keep it running. Some gsm modules I've seen require 15 volts, but others can run on as little as 5 volts. Manufacturers make a difference. The 5V out on an Arduino can be used to directly power a 5V module. Verify the Module Has TTL Output Pins Only if the gsm module is equipped with TTL output pins can data be sent directly to Arduino. If you want to use Arduino, you'll need to convert the RS232 data to TTL using a MAX232 IC. TTL output pins are standard on most commercially available gsm modules. Make sure you're getting the appropriate one before you buy.

Most commonly, the module is wired into a +4.0V supply. The module is safe to operate on +4.5V regulated power, and anything higher could potentially damage it. After all connections are established, we need to develop a programme for the microcontroller to communicate with the module, and the power source must be capable of delivering a peak current of 2A. For this reason, we will make use of libraries specifically designed for the module, as the data exchange sequence between controller and module is notoriously complicated. Libraries for controllers and modules can be downloaded from their respective websites. These libraries simplify interaction between parties. The controller communicates with the module through UART Interface according to the protocol defined by the library. The information is then transmitted via the cellular network to another GSM user by the module. The module will use UART serial communication to relay any information received from the cellular network (or another GSM user) to the controller.

WIFI Module

If your projects need access to the internet, the ESP8266 is a simple and inexpensive solution. The module may function as both an Access point and a station, allowing for easy data retrieval and upload over Wi-Fi, easing the burden of implementing the Internet of Things. It also has the ability to retrieve data from the internet utilising APIs, meaning that your project could gain access to any information on the web. One of the most intriguing aspects of this module is that it can be easily programmed with the popular Arduino IDE. The ESP-12 and ESP-32 variants are more self-sufficient, but the ESP-32 module has only 2 GPIO pins (which can be hacked to use up to 4).

Result

All of the on-board sensors are linked to the hardware via interface components. Included in the hardware are the microcontroller, LCD, dc motor, ADC converter, WIFI module, and all interfaced sensors. A SIM card is installed into the board so it may talk to its owner and send and receive data. Here you may see the

current temperature, humidity, and any detected intruders. Temperature, humidity, wetness, and intrusion detection are all calculated (fig.6).

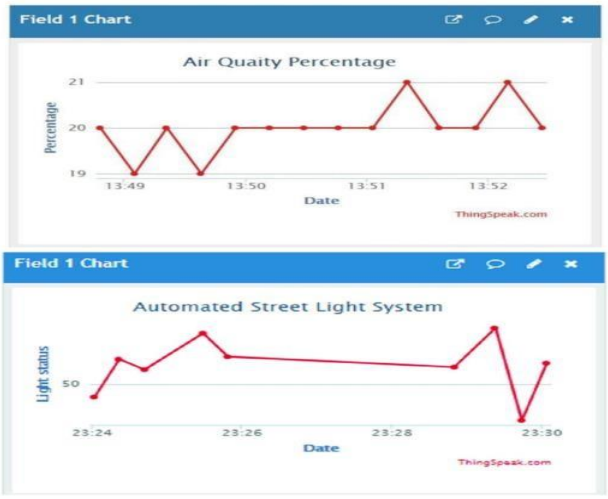

Fig. 6: output images

Conclusion

This means that our project raises people's consciousness concerning urban automation. The goal of the Smart City initiative is to enhance the standard of living of the local populace, fortify and diversify the economy, and put environmental sustainability at the forefront by using cutting-edge technological solutions. A measure of the success of these programmes will be their ability to improve people's lives and slow the rate of rising inequality in our country. By fostering the expansion and development of engaged citizens capable of comprehending and utilising digital solutions and services, Smart City technology will likely change sectors like healthcare, education, and policing in the future.

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