Integrated Media Street Operation System: Enhancing Urban Environments and Digital Out of Home (DOOH) Advertising Platforms

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Abstract

The media street operation system for outputting video content according to this study includes: A plurality of displays arranged above the entrance fronts of multiple stores located on either side of a roadway extending in a specific direction; A video database storing multiple video contents; An editing module that edits the video contents according to a set schedule and groups of displays to generate video pattern content; A central control server that includes an output control module to manage and control the output of the video pattern content to the displays based on the display groups and time slots. This media street operation system provides the effect of promoting landmark status and increasing foot traffic on the road where the media street is established by outputting video pattern content with continuity and consistency across multiple displays. A media street refers to a street equipped with multiple large LED screens installed along major roads or bustling areas with heavy foot traffic, where these large screens are interconnected to broadcast synchronized video content. Such a media street can provide a novel and unique experience to those passing by.This type of media street can highlight the application of cutting-edge technology in the area and provide a foundation for attracting more tourists. It aims to enhance the landmark status of the area, increase foot traffic, and revitalize the local business district.

Keywords: *Media Street, Digital Out of Home(DOOH) Advertisement, Digital Signage, Smart City Technology, Interactive Digital Displays, Video Content Management*

INTRODUCTION

Outdoor advertising has evolved in numerous ways, and the advent of DOOH (Digital Out-of-Home) has recently brought attention to the establishment of media streets within a smart city projects. Several key elements of this type of advertising are studied: digital marketing and what digital is; smart cities and the elements that the term “smart” is comprised of; the role of interactivity in advertising and especially outdoor advertising; the point of intersection between people, smart cities, the internet, digital marketing and digital outdoor advertising and interactivity. All of these elements would be analyzed through several case studies that reveal the effectiveness of digital OOH advertising in the scope of the smart city [1]. In the concept of the smart city, a media street typically encompasses a stretch where multiple large electronic billboards are strategically placed along bustling thoroughfares such as boulevards and main streets. Nam and Prado [2] discuss the difference between the term smart city and other terms that are used as substitutes – intelligent, digital and ubiquitous and also the three

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categories of technology, people and the community. These billboards are interconnected to display images, offering a unique and engaging experience for pedestrians passing through the area. These media streets showcase cutting-edge technology integrated into the urban landscape, aiming to attract tourists, boost foot traffic, and rejuvenate commercial districts, thereby positioning themselves as popular tourist destinations. Examples of areas that have established similar media streets in the past include Times Square in New York City, Piccadilly Circus in London, and Digital Streets in South Korea. Establishing a media street in these examples enabled regions to cultivate a prominent cultural identity. Beyond enhancing local landmarks and street aesthetics, these streets transmitted art and public interest content through images. In light of these successes, ongoing discussions focus on enhancing regional value through the creation of media streets in diverse locations. Implementing and managing a media street requires a system capable of interlinking multiple billboards effectively.

In response to this need, recent research has proposed a virtual image projection system. In recent years, the development of visualization systems is largely related to the dynamic growth of entirely new technologies: a projection of three-dimensional (3D) VR or so called augmented reality (AR) [3]. Many centers in the world attempted to construct devices (installations), allowing for unlimited territorial walk in a computer-generated

virtual world [4], [5], [6], [7], [8], [9], [10]. This system includes frames positioned on posts along the sides of a road, facing each other across the street, with screens mounted on these posts to span horizontally across the road. Virtual images are projected onto these screens, aligning with the vanishing point of the road boundary when viewed from a specific point along the road in front of the screen. Based on prior research, projecting images onto a screen spanning a road can obstruct signs and traffic lights, posing challenges. Installing screens on store fronts across the road to address this issue might obstruct the projected images. Therefore, there is a pressing need for an advanced video system capable of seamlessly and cohesively outputting images across media streets. This system should include multiple methods for image output, including autonomous image transmission mechanisms, rather than relying solely on projectors. Developing such a media street operating system is crucial for effectively delivering image content with continuity and unity.

Under these circumstances, this study aims to address the limitations of existing technologies by developing a systematic algorithm with four primary objectives. First and foremost, the goal is to create a media street operating system capable of seamlessly implementing a media street. This involves transmitting various processed images to multiple image output devices positioned along both sides of the road, ensuring continuity and uniformity. Secondly, the system aims to facilitate the transmission of diverse advertisements, including public interest campaigns, corporate promotions, and local advertisements, to these image output devices. Thirdly, the study seeks to provide a method for partitioning the display areas of the image output devices. This allows for the transmission of images that reflect the names and unique characteristics of stores located in corresponding areas along the street. Lastly, the system incorporates a feature to measure the ambient illuminance around the road. Based on these measurements, it adjusts the brightness of the image output devices accordingly, ensuring optimal visibility and efficiency.

MATERIALS & METHODS

To achieve the aforementioned objectives, the proposed media street operation system for image content output includes several components which are the multiple displays, image database, display groups, editing module, central control server. Multiple displays refer to screens or digital signage installations that are prominently positioned above the entrances of multiple stores located on both sides of the road, following the direction of the road's extension. An image database is a central repository that stores a diverse array of image content intended for display on multiple screens or digital signage installations. Display groups are structured arrangements that organize multiple displays into manageable units, often categorized by a specific number or logical division. This organization helps in efficiently managing and coordinating the content displayed across various sections of a media street or similar environment. The editing module is tasked with generating image pattern content by modifying stored images to meet specific time zone or scheduling requirements. This ensures that the displayed content is relevant and synchronized with the operational needs of the media street or similar display environment. The central control server is responsible for managing and distributing image pattern content across display groups and time zones within a media street or similar setup. Its role is crucial in ensuring that display operations are coordinated, synchronized, and aligned with the intended schedules and content requirements. Together, these components form a cohesive system designed to deliver continuous and uniform image content across the media street, accommodating various advertisements, local store promotions, and other relevant visual content efficiently and effectively.

Additionally, the system features a shared database where shop name content, tagged with store names for each store display, is stored. Each store display comprises a main display for outputting the aforementioned image pattern content and a sub-display for presenting shop name content. Within the output control module, there is a shop name content output control unit responsible for deciding whether to display shop name content on the sub-display concurrently with the main display showing image pattern content.

Moreover, the system incorporates a road illuminance sensor for measuring road illuminance, a sidewalk illuminance sensor for measuring sidewalk illuminance adjacent to the road, and a display illuminance sensor for measuring illuminance around the display itself. Within the central control server, there exists an illuminance numerical calculation module. This module computes illuminance values using data from the road illuminance sensor, sidewalk illuminance sensor, and display illuminance sensor. The output control module then adjusts the illuminance of image pattern content differentially based on varying levels of illuminance detected.

Hereafter, detailed descriptions of preferred embodiments of the present study will be provided, accompanied by reference to the accompanying drawings. The drawings are not to scale, and identical reference numbers in each drawing denote corresponding elements. Figure 1 illustrates a block diagram presenting the schematic configuration of the system proposed in this study, while figure 2 depicts a conceptual diagram illustrating an example of a media street.

As depicted in figure 1, the media street operational system discussed in this study comprises a display and a central control server (100). In this study, a media street refers to a thoroughfare established based on agreements and plans involving various interest groups such as local governments and commercial entities. Typically, these streets are situated in locations with high pedestrian traffic, such as boulevards and bustling urban streets.

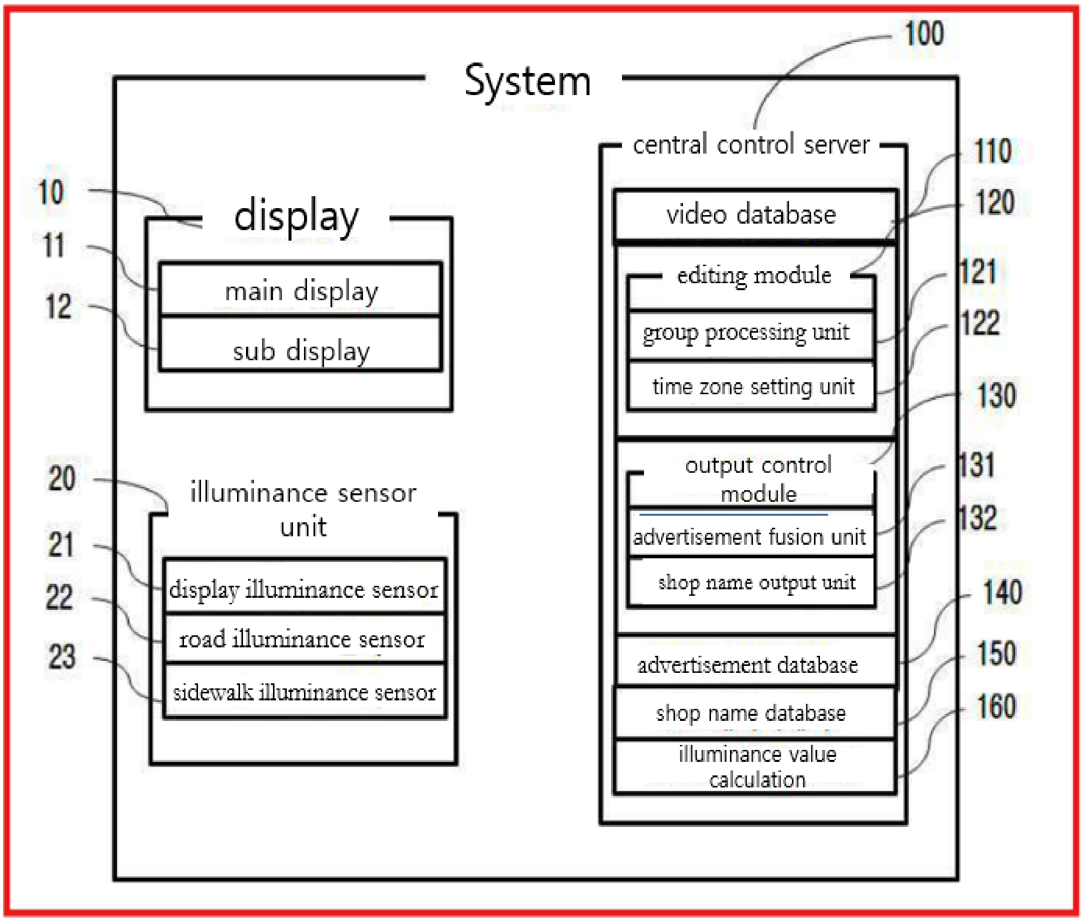

Figure 1. Conceptual diagram of the system

As illustrated in figure 2, the media street in this study features multiple electronic boards positioned along the street. These boards display edited images designed for continuity and cohesion, offering passers-by an experience distinct from typical streets. In this context, the electronic boards are referred to as 'displays' (designated as 'display 10' in this research), and the space between them is termed the 'road'. This setup ensures a unified visual experience for those navigating the street.

In essence, Media Street aims to create various values such as revitalizing local commercial districts, increasing pedestrian traffic, and establishing a prominent cultural identity within the region and commercial district. Media Street typically surrounds 'road', which runs through the heart of the city center with buildings lining both sides, forming a straight path along a bustling thoroughfare. This road serves as the foundation for achieving continuity and unity along the media street. In this study, 'road' can vary in length based on agreements and plans for creating a media street. Generally spanning several city blocks, road accommodates multiple displays strategically placed to maximize impact. Furthermore, buildings and public facilities flanking 'road 1' are collectively referred to as 'stores' in this study. Given the concentrated nature of commercial activity in city centers and downtown areas, each store is positioned closely to one another. Each store features an entrance facing the road, contributing to a familiar urban landscape. Naturally, a pedestrian sidewalk is situated between the stores and road, providing ample space for pedestrians to move about comfortably. This sidewalk is designed to offer opportunities for pedestrians to pause, explore, and enjoy various experiences such as admiring the surroundings of road or capturing moments through photography.

Figure 2. multiple electronic boards positioned along the street

Figure 3 provides a conceptual illustration of a media street where the system described in this study is implemented, while figure 4 depicts an example of image pattern content displayed on a screen positioned in front of a store. In this system, displays are positioned above the front entrances of each store, installed along the length of road. These displays employ various technologies such as LEDs, LCDs, and OLEDs capable of presenting image outputs. They are not limited to small screens but encompass medium to large-sized electronic boards typically used outdoors.

An example layout based on these display characteristics involves multiple displays arranged strategically. For instance, displays can be mounted at a consistent height along both sides of the buildings (stores). When viewed from the perspective of road, these displays can form two continuous bands along its length, as depicted in figure 3.

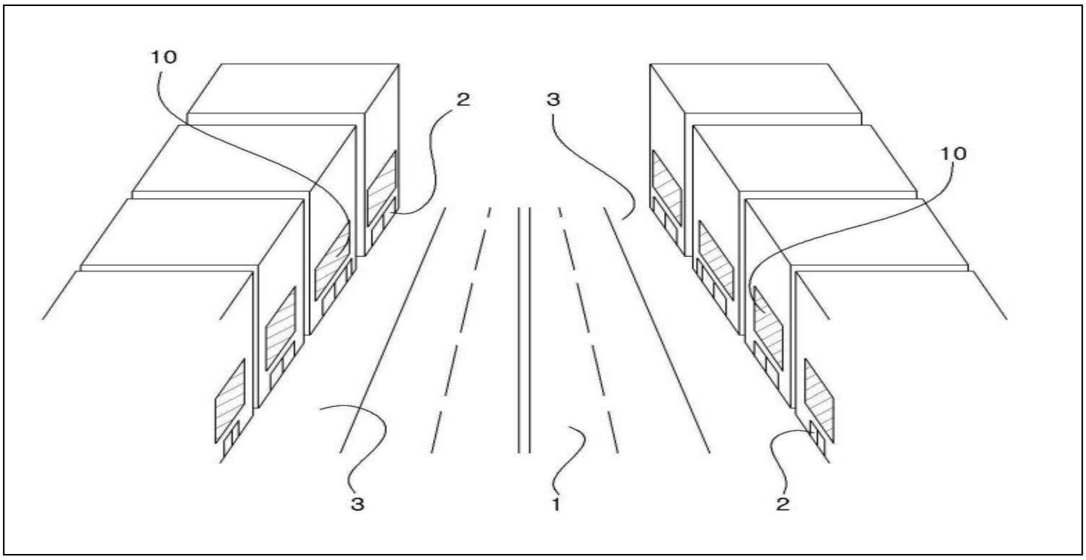

Figure 3. conceptual illustration of a media street

RESULT

Referring to figure 1, the central control server (100) of the system proposed in this study is basically based on four main factors which are the video database (110), advertisement database (140), shop name database (150), and illuminance value calculation module (160). Specifically, the central control server includes a video database (110), an editing module (120), and an output control module (130). The central control server is responsible for pre-storing and editing images, and then transmitting these edited images via the display to pedestrians and drivers. This system includes hardware components such as a CPU and storage units for processing information. In other words, the central control server 100 can run software by installing programs that utilize its central processing unit (CPU) and storage components, such as memory and hard disks, as well as its hardware-based wireless communication equipment, including wired and Bluetooth connections. Specifically, central control server might feature a random access memory (RAM) and a read-only memory (ROM) for both temporary and permanent storage of data.

Furthermore, the central control server could be designed as a system-on-chip (SoC), integrating components like a graphic processing unit (GPU), RAM, and ROM into a single chip. This setup may include a multi-core processor (cores not shown) and a connection pathway, such as a bus, for handling signal transmission between the processor, GPU, and other components. Programs, consisting of one or more instructions for controlling various modules or units, may be stored in memory. These programs can be segmented into multiple modules based on their functions.

The steps in the described method or algorithm can be implemented directly in hardware, as a software module executed by hardware, or as a combination of both. These software modules may reside on various storage media such as random access memory (RAM), read-only memory (ROM), erasable programmable ROM (EPROM), electrically erasable programmable ROM (EEPROM), flash memory, hard disks, removable disks, CD-ROMs, or any other computer-readable recording medium familiar to those skilled in the field. Essentially, the components of the central control server 100 can be implemented as programs or applications, which are stored in a medium and executed by hardware components like a computer. These components can be realized through software programming or software elements and may be developed using programming or scripting languages such as C, C++, Java, or Assembly. They may also include various algorithms implemented in data structures, processes, routines, or other programming components.

The term "module," "part," or "interface" refers to configurations of software or hardware such as FPGA or ASIC, executed through the CPU and memory and stored in the central control server 100's storage means. These configurations are not limited to hardware; they can also be stored in addressable storage media or be designed to run on one or more processors. For example, a "module," "part," or "interface" could encompass software components, object-oriented components, class components, task components, processes, functions, procedures, subroutines, code segments, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables. The functions provided by these "modules," "parts," or "interfaces" can be combined into fewer components or further divided into additional components, depending on the system's requirements.

Based on the overall architecture of the central control server, its detailed configuration and functions are as follows. The image database is a collection where multiple images are stored. In the context of this study, these images are termed 'image contents.' Image contents can include various types of visual material such as text, images, and videos, which are displayed on the display to communicate information visually. Additionally, the image content may comprise complex compositions that combine text, images, and videos into a cohesive, static presentation. Additionally, video content might include scenes such as a large number of firecrackers exploding simultaneously. When displayed across multiple displays, this can create the illusion for pedestrians and viewers of being part of a festival or event. The video content can encompass a range of materials including street promotions, corporate advertisements, public service announcements, video art, and performance videos. This variety allows the system to enhance the visual experience on road, adding benefits like increased profitability, public interest, and artistic value.

The editing module is responsible for processing and editing the image content over time, ensuring that it can be continuously shown across multiple displays. This module uses known image editing programs to perform these tasks. In the context of this study, the image content that has been edited by the editing module is referred to as 'image pattern content.'

Specifically, the editing module may comprise two key components: a group processing unit (121) and a time zone setting unit (122). Group processing unit is responsible for organizing and managing multiple displays by grouping them. It connects a predetermined number of displays into a 'display group,' allowing coordinated display of content across these linked screens. Time zone setting unit includes applications or programs for time management. It sets time zones for transmitting the image pattern content, which can be synchronized with a portal site to manage when and where the content is displayed. The editing module not only ensures that image pattern content is displayed continuously across the display group but also enhances the aesthetic effect and uniformity of the content. It achieves this by editing and transmitting content differently according to the specific display group and the timing of transmission, thereby maximizing visual appeal and coherence across the screens.

The output control module is responsible for transmitting image pattern content to displays, essentially managing how and when the content is shown. This module ensures that the edited image pattern content is projected onto the displays according to the designated display group and time zone, allowing pedestrians and drivers to view and enjoy the content as they pass by. In summary, this system offers the ability to create diverse value, such as revitalizing local commercial areas and enhancing cultural visibility, by delivering image pattern content with continuity and coherence across media streets lined with displays.

The central control server also includes an advertisement database (140), which serves as a repository for various advertisements that can be displayed. This database holds advertisement content, which is ideally a video advertisement designed to play seamlessly across multiple displays. However, it can also include other types of advertisements. The advertisement content may encompass a range of promotional materials, such as promotional videos for roads, large companies, individual stores, or public interest campaigns.

In alignment with this, the output control module may include an advertisement fusion output unit (131). This unit manages the selection and output of either image pattern content or advertisement content to the displays. It determines whether to display image pattern content based on the specific display group and time zone or to show advertisement content. By incorporating this functionality, the system can boost the profitability of the media street. This capability enhances the attractiveness of the displays for advertisers, encouraging more investment and increasing engagement within local commercial areas.

The system described may include a shop name database. This database stores information indicating the names of individual stores, referred to as "shop name content." This content reflects the store's name and business type and can be displayed in various formats, including text, images, and videos. The goal of the shop name content is to inform pedestrians about the store's name and business type, rather than focusing solely on the uniformity of the road. It allows for creative and flexible presentation of shop names according to the store's needs. The display setup might include a main display (11) and a sub-display (12), as illustrated in figure 4. The main display is used to output image pattern content and provides its primary display functions. The sub-display is positioned beneath the main display and near the store entrance, specifically for displaying shop name content. This arrangement allows the sub-display to serve as a store sign, showcasing each store's name and role effectively.

To manage this, the output control module may feature a shop name content output control unit (132). This unit controls the display of shop name content on the sub-display while simultaneously managing the output of image pattern content on the main display. Essentially, it decides whether to show shop name content or image pattern content, ensuring that each store receives promotional visibility through the sub-display. This feature enhances the media street’s appeal and encourages store participation, contributing to the creation of an engaging and dynamic street environment.

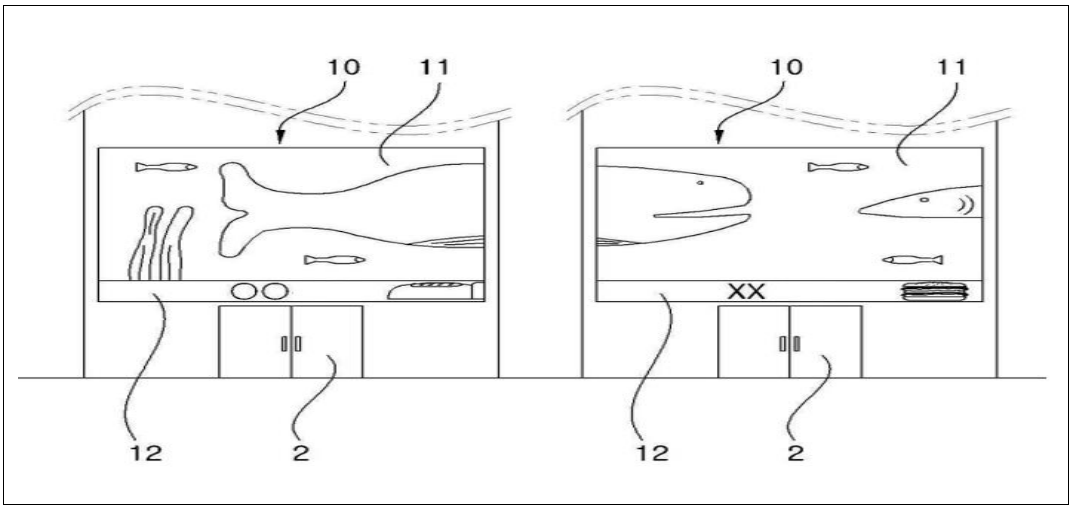

Figure 4. The display setup

Furthermore, the system described may include an illuminance sensor unit (20). This unit is equipped with multiple illuminance sensors, which measure light levels using a property where resistance increases as light intensity increases, such as those utilizing a cadmium sulfide element. The illuminance sensors are distributed around roads, sidewalks, and displays to measure ambient light levels. In this context, The sensor measuring road illuminance is referred to as the road illuminance sensor (22). The sensor measuring sidewalk illuminance is referred to as the sidewalk illuminance sensor (23). The sensor measuring display ambient illuminance is referred to as the display illuminance sensor (21).

The central control server is equipped with an illuminance value calculation module (160). This module calculates the illuminance values based on the readings from the road illuminance sensor, sidewalk illuminance sensor, and display illuminance sensor. These illuminance values help determine the appropriate brightness levels for the image pattern content displayed on the screens. The illuminance value is used to assess the light levels of different sections of the road and serves as a relative criterion for setting the display brightness. The illuminance value may be calculated using an equation like the following:

$$Q = \left(\frac{aX + 2(1n(bY))^3) + cZ}{K \times \log(X + Y + Z)} \right)$$

Here, Q represents the illuminance value, X denotes the display illuminance, Y is the road illuminance, Z signifies the sidewalk illuminance, a, b, and c are weights (with constraints $2.1 \leq a < 2.3$, $1.6 \leq b < 1.8$, $0.6 \leq c < 0.8$) and K is the standard deviation of X, Y, and Z)

Equation 1 assigns different weights to display illuminance, road illuminance, and sidewalk illuminance to balance their impacts on visibility and safety. Specifically: Display Illuminance (X) is given the highest weight, reflecting its critical importance in ensuring that image pattern content remains visible even if the surrounding light levels are high. Sidewalk Illuminance (Z) receives a weight lower than 1. This adjustment accounts for the need to keep the sidewalk illuminated for pedestrian safety while still ensuring the content on the display can be seen. The lower weight helps balance the need for visibility against the practical constraint of not being able to dim the sidewalk lighting too much. Road Illuminance is given the lowest weight, this reflects the significant variability in road lighting due to vehicle headlights and the potential for glare, which can affect driver focus. A natural logarithm is used to moderate its effect and prevent excessive influence on the brightness settings. The weight is set between 1.5 and 1.8 to account for the fact that the natural logarithm may reduce the numerical value compared to other illuminances. The formula also incorporates the standard deviation Q does not become excessively high, thus providing a practical and balanced approach for adjusting display brightness while considering all relevant factors.

Additionally, the system of this study may include a filter panel. The filter panel is installed on the front surface of the display (the side where the video pattern content is output), and serves to protect the display from impacts and dust intrusion. Moreover, the filter panel may be installed at a certain distance from the display via a plurality of block-shaped supports (preferably four or more) provided on one side of the front surface of the display. In this case, if the filter panel is installed in close contact with the display, it helps prevent the accumulation of heat between the filter panel and the display. This filter panel includes transparent materials such as polypropylene (PP), polyethylene terephthalate (PET), and polymethyl methacrylate (PMMA), which do not hinder the transmission of video pattern content. Additionally, the filter panel may include a base composed of polymethyl methacrylate, with a layer of antistatic agent containing doped polypyrrole (with dodecylbenzenesulfonic acid) layered on top. Here, the polymethyl methacrylate included in the base serves as a conductive polymer, providing a foundation that allows the antistatic agent to maintain its function by conducting electricity. Furthermore, polymethyl methacrylate is transparent, allowing light to pass through.

Furthermore, the antistatic agent possesses electrical conductivity to prevent the accumulation of static electricity, thereby preventing dust from adhering to the surface. Specifically, the antistatic agent contains polypyrrole doped with dodecylbenzenesulfonic acid. Polypyrrole is a polymer with excellent electrical conductivity and transparency, serving as the primary material to implement the antistatic function. Dodecylbenzenesulfonic acid is a substance that enhances the electrical conductivity of polypyrrole, dissociating into anions that can be doped into the polypyrrole during the polymerization process. In other words, polypyrrole doped with dodecylbenzenesulfonic acid effectively reinforces the excellent electrical conductivity of polypyrrole, thereby effectively preventing dust from sticking to the surface of the filter panel, particularly the surface of the base. Additionally, it is inherently transparent, which does not significantly hinder light transmission through the filter panel.

The specific manufacturing method for the antistatic agent containing dodecylbenzenesulfonic acid-doped polypyrrole is as follows. Figure 5 is a flowchart illustrating the method for manufacturing the antistatic agent of this study. As seen in figure 5, the antistatic agent of the present research can be manufactured through primary substance manufacturing (S100), secondary substance manufacturing (S110), tertiary substance manufacturing (S120), and mixing (S130).

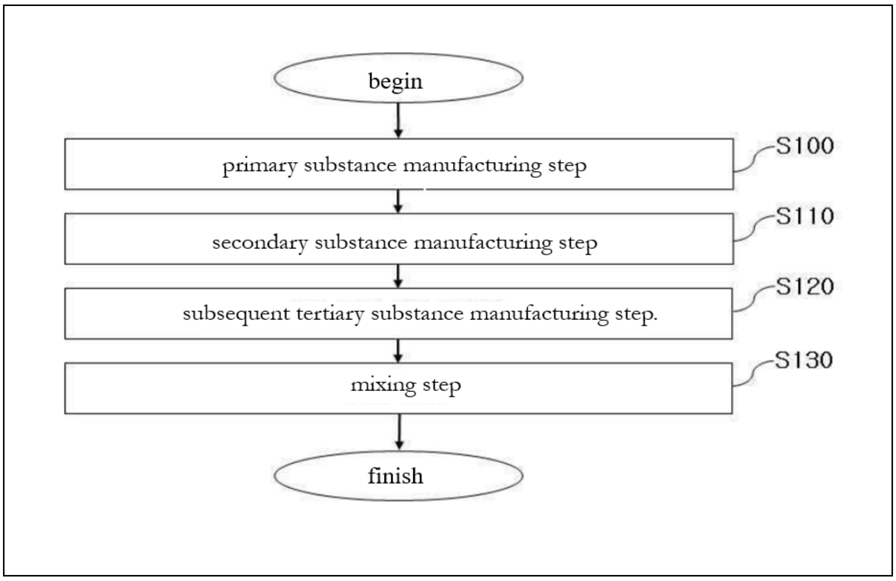

Figure 5. flowchart illustrating the method for manufacturing the antistatic agent

First, the primary substance manufacturing step (S100) involves mixing 50 to 60 weight parts of water, 30 to 40 weight parts of pyrrole, and 10 to 30 weight parts of dodecylbenzenesulfonic acid at 20 to 40℃ for 1 to 3 hours, then cooling to 0 to 10℃ to produce the primary substance. In this step, pyrrole is the monomer for the conductive polymer polypyrrole, and dodecylbenzenesulfonic acid, as mentioned, is a substance that dopes polypyrrole during polymerization to enhance conductivity. Additionally, water acts as the dispersion medium for the primary substance, helping to dissociate dodecylbenzenesulfonic acid into anions for doping into the polypyrrole. Pyrrole and dodecylbenzenesulfonic acid serve as the foundational materials for polymerization into dodecylbenzenesulfonic acid-doped polypyrrole in the subsequent tertiary substance manufacturing step (S120).

Next, the secondary substance manufacturing step (S110) involves mixing 70 to 80 weight parts of ethanol and 20 to 30 weight parts of ammonium persulfate at 20 to 40℃ for 10 to 30 minutes to produce the secondary substance. Ammonium persulfate acts as an oxidizer and initiator, inducing polymerization of polypyrrole and doping with dodecylbenzenesulfonic acid in the subsequent tertiary substance manufacturing step. Ethanol serves as the solvent for the secondary substance, allowing even dispersion of ammonium persulfate. Following this, the tertiary substance manufacturing step (S120) involves mixing 60 to 70 weight parts of the primary substance with 30 to 40 weight parts of the secondary substance at 0 to 10℃ for 3 to 5 hours, then precipitating for 30 to 60 minutes and removing the supernatant to produce the tertiary substance. The tertiary substance produced through this process is dodecylbenzenesulfonic acid-doped polypyrrole, which plays a key role in minimizing static electricity generation through its electrical conductivity. The tertiary substance should be ground to a particle size of 10 to 50 µm for even dispersion in the antistatic agent.

Finally, the mixing step (S130) involves mixing 80 to 90 weight parts of the tertiary substance with 10 to 20 weight parts of an adhesive auxiliary containing 2-hydroxyethyl methacrylate and sodium lauryl sulfate at 60 to 90℃ with a rotation speed of 30 to 50 rpm. The adhesive auxiliary helps adhere the antistatic agent to the base while maintaining transparency, preventing interference with visual transmission of the video pattern content. The adhesive auxiliary is mixed at the specified speed to avoid load on the mixing equipment, as it is in a high-viscosity gel form. The detailed manufacturing method for the adhesive auxiliary will be described later. The antistatic agent manufactured through this process provides functionality to prevent static electricity buildup, thus reducing the likelihood of dust adhering to the filter panel installed outdoors, which could otherwise obscure the video pattern content or pose a fire hazard due to sparks from accumulated dust.

DISCUSSION

The proposed media street operation system represents a significant advancement in urban visual communications, offering multiple benefits that can transform both the aesthetic appeal and economic vitality of city areas. This system’s ability to provide consistent video pattern content across multiple displays has the potential to create a visually cohesive and recognizable urban landmark. By establishing a unified visual identity, it can enhance the area's visibility and prominence, thereby attracting increased foot traffic, which is particularly valuable in bustling urban environments where capturing passersby’s attention is crucial. Additionally, integrating advertising content into these displays introduces a lucrative opportunity for revenue generation, as the system’s capacity to showcase targeted advertisements can boost its appeal to businesses and advertisers. Evaluating the effectiveness of different advertising strategies by analyzing viewer demographics and engagement metrics is essential, and it is important to consider how the balance between advertising and non-commercial content impacts the overall viewer experience. Furthermore, displaying the names of nearby stores fosters community engagement and strengthens local business participation, thereby supporting the local economy and creating a more interconnected urban environment. Evaluating the impact of this feature on local business sales and community relations will provide valuable insights into its effectiveness. The system’s ability to adjust the brightness of video content based on surrounding lighting conditions ensures that the media content remains visible and clear regardless of environmental changes, such as varying levels of daylight or nighttime conditions. Future research should explore the effectiveness of different adaptive technologies and their impact on content visibility and user experience. While the media street operation system offers a comprehensive solution for enhancing urban visual experiences, several areas warrant further investigation. Research could focus on optimizing content management systems to handle diverse and dynamic content more efficiently and studying user feedback and behavioral responses to different types of content to improve system design and functionality. Exploring the long-term impacts on urban development and local business ecosystems will also be valuable for assessing the system's broader implications.

In conclusion, the media street operation system holds significant promise for reshaping urban landscapes through dynamic visual experiences, and by addressing potential challenges and continuing to innovate, it has the potential to contribute positively to both the economic and social aspects of city life.

Acknowledgement

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea(NRF-2023S1A5A2A01078140)

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