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Visualisation Method for Effective Traffic Management Within Smart Cities

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Abstract: Visualisations systems play a great role in efficiently and intelligently managing the traffic especially in smart cities. The visualisation systems helps in reading the traffic ahead of the actual congestion and so makes the traffic flow smooth and clear. One of the major task however will be to position the visualisation systems in strategic locations and communicate with the same from different location such as traffic post, local and remote controlling stations. The visualisation system must be composite that it supports different visualisationmechanisms and intelligent that it must communicate using multiple modes of communication that uses different mediums which includes, optic fibre, wireless, cellular, satellite and microwave. In this study, a visualisation system that is composite and intelligent is presented that can be seamlessly implemented into a smart city system.

Key words: Smart city, visualisation, traffic management system, communication systans

INTRODUCTION

Visualization is a technique of creating images, diagrams or animations to communicate a message without ambiguity. Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the beginning of mankind. The inventions of computer graphics lead to development of efficient visualisation systems. Further, invention of multimedia techniques has helped to introduce animation into visualisation systems which in fact is quite advancement. Most advanced is the representation of geographic or spatial data as in thematic cartography using statistical graphics. Visualisation per say can be categorised into scientific visualisation, educational visualization, information visualization, information visualization, knowledge visualisation, product visualization and for visual communication. In scientific visualization the data from simulations or experiments, have to undergo transformation, selection, alternately representational of information starting with simulations or experiments. Thevisualisation structures which are geometric in nature should permit exploration, analysis and comprehension of the information. Scientific visualization concentrates and emphasizes the use of higher representational information in terms of graphicsand use of liveliness strategies. The exploratory visualization needs aid stream visualization, therapeutic visualization, astrophysical visualization and concoction visualization. Several kinds of strategies are required to present exploratory data. In educational visualization, a simulation is usually created on a computer to create an image of something so it can be taught about. This is very useful for teaching topics such as atomic structure because atoms are far too small to be studied easily and it is expensive and difficult to use scientific equipment.

To explore large amount of abstract data using computersupported tools one needs theinformation visualization. It involves selecting, transforming and representing abstract data in a form that facilitates human interaction for exploration and understandingin computer programs. Important aspects of information visualization are dynamics of visual representation and the interactivity. Visualisation of the knowledge that has been discovered from databases is one of the most important areas of study.Samples for such visual formats incorporates sketches, diagrams, images, objects, interactive visualizations, knowledge visualization applications, Sometimes majority of the knowledge visualization focuses on the utilization of computer-supported devices Knowledge visualization presents experiences, attitudes, values, expectations, perspectives and predictions.

Product visualization requires the use of 3D models especially for presenting the, technical drawings and other related documents of large assemblies of products and manufactured components. It is the key part of product lifecycle management. By using product visualization software, one can view the product before it is actually manufactured. Through product visualisation

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differentfunctions ranging from design and styling to sales and marketing can be implemented. In visual communicationthe ideas are communicated through the visual display of information. It is associated primarily with two dimensional images and it includes alphanumeric, signs, artand also electronic resources. In recent time the aspect of visualisation is dealt focused on web design and graphicoriented usability.

Human interaction with visualization systems are focused as part of a larger process of data analysis in visual analytics. Visual analytics can also be defined as "the science of analytical reasoning which is supported by the interactive visual interface". Its focus mainly on human information discourse within massive, dynamically changing information spaces. It concentrates on usage for perceptual and cognitive operations that helps users to detect the expected and discover the unexpected in complex information spaces. The technologies resulting from visual analytics find their application in almost every field but are being used excessively in biology and national security. Road traffic control will involve in directing vehicle and pedestrian traffic around a construction zone, accident or other road failure, thus ensuring the safety of emergency response teams, construction workers and the general public. Traffic Management system involves planning, monitoring and control of traffic. Traffic management systems aims at effective use of existing infrastructure and ensure reliable and safe operation of transport

The number of vehicles on the roads is expected to be doubled to around 2.5 billion by 2050 leading to increase in congestion, pollution, collisions affecting the commuters. More and more roads are being constructed to deal with traffic and make the flow smooth.Many technologies have come up that helps a person to move from one location to the other with ease. Sensors installed alongside the roads, on top of the vehicles and signal posts are being used to collect data based on which predictive analysis can be carried based on which the traffic congestion can be controlled.Drivers use social media to detect and avoid gridlock. City planners analyse data from point to point where new bus routes are most needed. Even the way we park is being renewed. Cities all over the world are facing rapid growth and mounting transportation challenges. But that growth provides opportunities to build an intelligent transportation system that will fundamentally improve the cities to manage and citizens use their transportation networks.

Over the last 10 years, computer based visualization technology has been developed into a powerful aid for studying a variety of natural phenomena and has become an indispensable desktop technology for supporting professionals in the areas such as medicine, architecture and engineering. Continuous advances in computer technology have made these sophisticated visualization techniques available and affordable to the transportation industry.

In transportation, visualization is a science that combines a variety of different applications and technologies such as composite image, video overlay, animation and Geographic Information System (GIS) to realistically generate and portray existing and proposed project conditions. Effective visualization significantly improves the ability to assess complex planning scenarios and proposed alternatives. It can be used to identify and solve potential problems early in the project development process, produce and evaluate alternatives faster and facilitate early public involvement and feedback.

Because of the difficulty in communicating the complex nature of transportation projects, visual aids are necessary for public presentation. The intent of visualization in public presentation is to help the public understand the context, to add insight to problem solving and to communicate with the public. It is used to communicate the effects of future changes and modifications to our transportation system. Visualization can be effectively employed to communicate the reasons that make the project necessary. It needs to be incorporated into the public presentation process to give the visual nature of the project and the effect it will have on the environment. Visualization can also be implemented to evaluate the cost and functional effectiveness of alternative solutions, the advantage of the project to the public as well as the anticipated impact.

Geometrical data in transportation is often characterized by high level of complexity that makes it difficult for even designers to understand the full spectrum of issues. For example, the complexity of horizontal and vertical alignments, sight distance and traffic operations in some large-scale projects (such as interchange construction) cannot be fully understood without visual support. Due to the complexity of the geometrical data, the need to analyse and test the design idea is growing in importance for transportation engineers. Traditionally, the testing of a design can be accomplished through CAD drawing which is based on numerical models. However, this traditional procedure illustrates little about the project performance which is determined by experiencing the design and simulating its operation. Through various visualization technologies, design ideas can be visualized by providing a real time visual representation.

Visualization products provide information in a stimulating, visual way. They convey complex information in easily digested segments. Visualization enables people to deal with information by taking advantage of ones innate visual perception capabilities. By presenting information more graphically, it is possible for human brain to use more of its perceptual system in initially processing information, rather than immediately relying entirely on the cognitive system that will provide some insight into the relationship between perception and visualization. In anticipation of the need to strategically manage the traffic conditions, a new generation of visualisation using variable messaging system is required for effective display of visualisation. All adverse conditions must be taken into account while designing the Visualisation systems. The visualisation systems should be able display variety of visualisations that include animations, 2D/3D graphics, text displays, display of banners etc. The visualisation must be 100% accurate and must be available all the time with the help of alternate routes for effective communication. The visualisation system must support different modes of communication to support transmission of messages from the traffic monitoring and controlling system that are located either at small or long distances. Thus the visualisation system must be composite that it supports various types of visualisations and also can be communicated using different modes based on the distances at which the visualisation systems are located.

MATERIALS AND METHODS

Overview of existing display systems: Visualisation for traffic management can be achieved by display systems. Display systems like graphic route information panels, dynamo LED displays are traffic control devices used to provide motorists route traveller information. They are commonly installed on fully span overhead sign bridges, mounted on roadway shoulders and overhead cantilever structures. The information is most often displayed in a real-time and can be controlled either from a remote centralized location or locally at the site. Display systems are designed to affect motorist behaviour to improve traffic flow and operations. Traveller information displayed on displays may be generated as a result of a planned or unplanned event which is programmed or scheduled by operations personnel. Examples of traveller information include Travel times between known destinations, congestion conditions along a freeway corridor, construction notices, special event notice and motorist instructions, Maintenance operations schedule, pending severe weather announcement andIncident notification

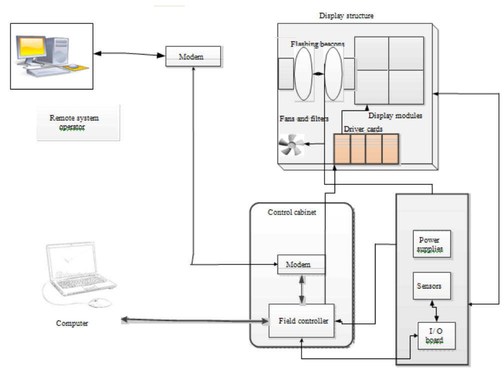

Fig. 1: Display system

The objective of providing the information is to allow the motorist time to avoid an incident, prepare for unavoidable conditions, or to give travel directions. For all information displayed, the goal is to have a positive impact on the motorist's travel time. Figure 1 shows a typical layout of a display system.

Sign structures are normally constructed with aluminium with clear, anti-glare, Lexan facings. Some new displays have exposed LEDs or lenses. These structures are designed to be resilient against temperature and other weather conditions. Most of the major display components are contained within the display structure. Flashers or beacons are used to draw attention to a sign when an important message is being displayed. They can be found within the sign face or can be mounted to the top of the sign structure, or they can be on nearby poles. Display modules are contained within the sign structure and make the display matrix. Each module will consist of numerous pixels. These pixels are configured in columns and rows. When they are activated together, pixels form characters, numbers and letters. With a group of multiple modules, messages can be displayed.

Display drivers are circuitry that control the data output to the display modules. There is typically one driver per module, though some signs contain row and column drivers, or even one driver that controls multiple modules. Drivers are located on or near the display module they control. Newer displays are integrating the drivers onto the display module circuitry. The display drivers are addressable and set per the module's location in the display matrix. This ensures the desired character will be displayed on the correct module.

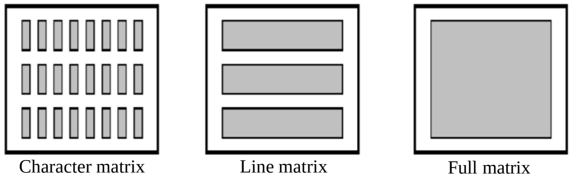

Fig. 2: Types of matrix displays

Al display systems need power supply systems: They contain multiple DC power supplies that energize modules and other components. These power supplies can be redundant, meaning that if one fails, another will compensate. This allows for uninterrupted display operations.

The sign systems: contain multiple sensors that allow the field controller to adapt to environmental changes.Temperature Sensorstake internal and external temperature readings. The field controller reacts accordingly, to either heat or cools the VMS. Light Sensors record external ambient light levels. The field controller changes the display intensity level to compensate for day and night conditions.The fans are activated by the field controller and it maintains proper operating temperatures and airflow within the display environment.Filters are used to have a dust-free display system environment. Most displays contains intake and exhaust filters. Filter locations may vary from one manufacturer to the other.

The cabinets are generally located near the sign structure. Depending on the manufacturer, the cabinet can house AC load centres, modems, fibre components, communication punch-down blocks and field controllers. Field controlleris the central processor for a displaying system. The field controller contains memory for message and schedule storage. It controls the display outputs and all peripherals within the sign. Communication with the controller can be locally or remotely via a computer.

The input/output circuit board will monitor all the sensor outputs. It will also control beacons and other relay controlled devices. Its output allows the field controller to respond to sensor changes as needed. Modems will allow the operator to communicate to the field controller from a remote location. Remote Communication can be through copper or optical fibre. Different types of display systems are shown in Fig. 2. Messages displayed on a display system are done by using single or multiple-phases. A phase is defined as the limits of the display area available for text, bitmaps or animation. Messages that require more information than can be shown on a single display space may require the use of multiple phases. Multiple phases allow more than one message to be displayed at a location. Many complexities have to be considered and handled which arises when visualisation systems are used as means of regulating the traffic. Some of the complexities that must be handled include inability to display exact visualisations during adverse weather conditions, failure of communication links either through local signal posting systems, local earth station or remote central traffic management system, lack of alternate paths for communication, Sluggish response from visualisation system due to poor streaming

Literature review: Chen *et al*. (2015) made a survey regarding how the data is driven from intelligent transportation systems using the data resources generated within the intelligent systems to improve the performance of transportation systems and provide convenient and reliable services. Trafic data refer to datasets generated and collected on moving vehicles and objects. Data visualization is an efficient means to represent distributions and structures of data sets and reveal hidden patterns in the data. They introduced the basic concept of trafic data visualization, provides an overview of related data processing techniques and brief theory of existing methods for depicting the temporal, spatial, numerical and categorical properties of trafic data.

Evaluating the tasks of existing trafic data analysis applications, the tasks of trafic data visualization could be classied as visual monitoring of trafic situations, pattern discovery and clustering, situation-aware exploration and prediction, location based, activity-based and device-based visualisation. Journal TR news (2007) emphasis on the need of visualisation in transportation which has become a catch-all for many visually enhanced applications that have found their way into the transportation industry-such as modelling, animation, simulation and virtual reality-to improve the ability to fund, develop and deliver timely, cost-effective and safe transportation systems in synch with society's needs.

Walton (2016) represented a real-time method for transforming video information in quasi-3D to spatial information in a 2D planar visualisation which acts as a live layer on top of a conventional satellite image-based mapping system. Here video cameras are a ubiquitous and intuitive means of collecting trafic information. It has

Table 1: Different parameters required for traffic management systems

Parameters	Cross/Arrow displays	Free/Occupied displays	Alphanumerical graphic display
Pixel pitch	16 mm	12.5 mm	16/2/25 mm
Colour	green-arrow; red-cross	1 colour/content	1, 2 or 3 colours
Reading angle	>150° (indoor version); 70°/30° (outdoor version)	70°/30°	>150° (indoor version); 70°/30° (outdoor version)
Communication	Serial RS-422/485; input control	Change of content via relays	Serial RS-422/485, input control, ethernet (optional)
Housing dimensions	200×200×60 mm	610×115×130 mm	depend on the selected pixel pitch and number of characters
Mechanical protection	IP54	IP43-meant for integration	IP54

been difficult to utilize such an information source for creating a global view in real time trafic visualisation. To reach the requirement of rapid and reliable camera-map calibration, a semi-automatic calibration scheme has been proposed. The scheme allows users to pre-define essential projection attributes for each camera in a set-up stage and map these video streams onto a live layer of the map. They also suggested several schemes for visually mapping information extracted from videos including trafic speed and density and uncertainty. Wolfgang kastner proposed modern traffic technology for information propagation from a higher order control unit to the traffic participant. In today's systems, the user interface for the traffic participant is provided via programmable signs displaying traffic jam problems, speed limits or route diversion. These signs can be switched in on or off condition andfed with arbitrary data corresponding to the present traffic situation. However, signs are manifold in sizewith functionality and means to communicate with them. Wolfgang kanster proposes a component based software architecture that allows a rapid integration of such signs into existing traffic management systems. Lu *et al*. (2006) describes that, Transportation and the highway network appears as the backbone of the total public infrastructure system. As such, planning and observing for an effective transport system plays a crucial role in building and maintenance of a region's economy and safety. However, demand for road transport increases as the population increases, especially in the metropolitan areas, while new constructions are not in practice. According to Federal Highway Administration, it is informed that the volume of freight movement alone is nearly double by 2020. Congestion and looming gridlock crises may seriously threaten any region's mobility, safety and economic vitality. A crucial component in addressing these problems is the development of specific technologies to monitor, model and optimize traffic flow.

According to the Imawan and Kwon (2015) survey, the rapid converging of big data and IoT (Internet of Things) technologies provides more opportunities in the area of road trafic applications. Ardi Imawanpresented a timeline visualization tool which enables us to better understand trafic behaviour from road trafic big data. Student handbook on Introduction to variable message signs describes about the existing display technologies, Various variable message sign and the function of each within the sign system. It also describes about the common communication types involved in the display system. In Wisconsin Department of Transportation Design Manual ofIntelligent Transportation Systems (ITS) there is a brief introduction of variable message signs and it usage in real life traffic monitoring (DOT, 2010).

Parametric identification for effecting efficient visualisation: Visualisation thus is the most important aspect that one must consider while trying to build an intelligent traffic system for a smart city. The parameters that determine a display system include pixel pitch, colour, readingangle, communication, housing dimensions, mechanical protectionfor different displays likecross/arrow displays, free/occupied displays and alphanumerical graphic display. Pixel pitch is the shortest distance from the centre of one pixel to the centre of the next pixel. The IP code, international protection marking, IEC standard 60529, sometimes interpreted as ingress protection marking, classifies and rates the degree of protection provided against intrusion (body parts such as hands and fingers), dust, accidental contact and water by mechanical casings and electrical enclosures. Table 1 describes the various parameters that must be considered while either designing or selecting display systems of different types. Different types of display systems uses different parameters with different specification altogether. Alphanumerical graphic display provides highest visualisation support but it is also limited by its ability to communicate using RS232C communication only which is a real serious drawn back from implementing intelligent traffic management systems as the such a system requires different types of communication systems. A typical networking architecture that deals with various modes of communication for effecting traffic management has been shown in Fig. 3.

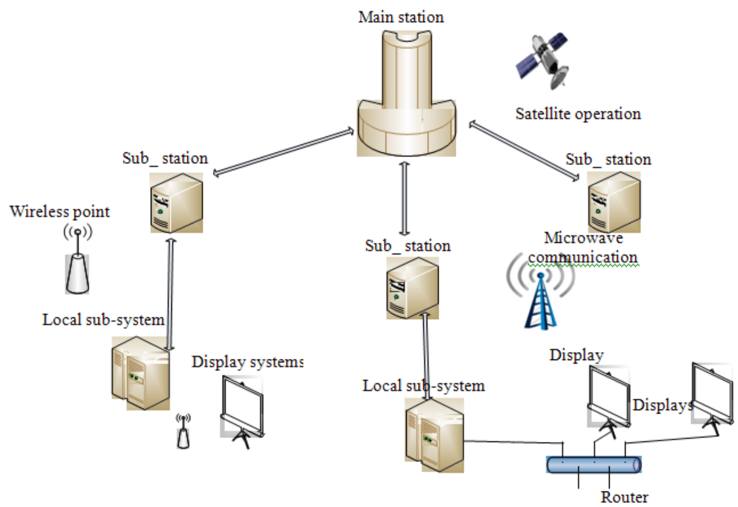

Fig. 3: Networking architecture

Table 2: Comparisons of different display boards

Property	GS6	MS4	AMI	Data sign C5
Text	Fully programmable	Fully programmable	Fully programmable	Fully programmable
Graphics	Standard legendsand symbols, videos	Standard legendsand symbols	Standard texts and symbols	Standard texts and symbols
Communication protocol	Depending on usage	NMCS2,others available	NMCS2	Depending on usage
Communication	1 x RJ45 Ethernet	RS485 standard, others available	RS485 standard, others available	Depending on usage
Luminous intensity	All colours, with brightness 250 cd/m^2	Red >3100 cd/m^2 Amber >7440 cd/m^2	White >12,400 cd/m^2 Green >3,720 cd/m^2 Red >3,100 cd/m^2	5-Colour VMS
Brightness levels	16	16	16	16
Temperature	-20°C to +60°C	-20°C to 60°C	-20°C to +60°C	-20°C to 60°C
GPS tracking	No	No	No	Yes
Solar power	No	No	No	Yes
Fire Info.	No	No	No	Yes
Automatic weather condition display	No	No	No	No

Comparative analysis of existing visualisation systems: Various types of display systems are in use. The display systems differ in characteristics which uses different types of parameters for affectinga specific display system. Table 2 show the properties used by different display systems that are being used at present to display data, messages or videos. GS6 series is manufactured by Daktronics and can be used to display videos and is used forremote access and automatic monitoring. Display board MS4 Series offers a modular full graphics area with a matrix of LEDs in two colours. This makes it capable of displaying an almost infinite range of pictograms and legends. The AMI (Advanced Motorway Indicator) from variable message signs limited has been developed to meet the ever-changing needs of traffic authorities whilst fulfilling the expectations of the motorist.Designed and manufactured by Data Signs, the DATASIGN-C5 can display any range of messages composed of letters, symbols and animations in 5 different high visibility colours. The DATASIGN-C5 is a must for efficient local traffic management, roadwork safety and is a very effective advertising tool.

RESULTS AND DISCUSSION

On finding efficient visualisation systems for traffic management: The most important challenge is to find most suitable set of display systems or a combination of them so that a composite display system can be evolved and meets all the visualisation requirements of an intelligent traffic system. Table 3 shows the functional requirements that are related visualisation which needs to be supported within an intelligent traffic management system and the extent to which the functional requirements could be met by various visualisation systems that are being used in the market as on today. From the Table 3, we can notice that none of the above display systems are able to meet our requirements for effective traffic management system. Hence, there is a

Table 3: Applicability of visualisation system for traffic management

Application requirements	GS6	MS4	AMI	Data sign C5
To be able to display under extreme weather conditions	Yes	Yes	Yes	Yes
To be able to support clustered display	No	No	No	No
Must be able to display animations	Yes	No	No	Yes
Must be able to display matrix based messages	Yes	Yes	Yes	Yes
Shall have necessary interface to communicate using Different protocols	No	No	No	No
Must be able play video displays	Yes	No	No	No
Must support different streaming speeds	2.5 Mbps	Depends on programming	Depends on programming	Depends on programming

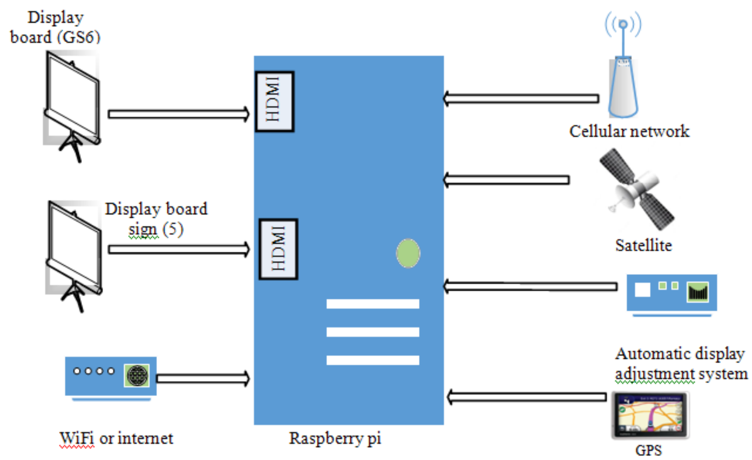

Fig. 4: Composite system for effecting visualisation for traffic management

necessity to design a new composite visualisation system which will meet all our required features for effective visualisation.

Designing composite and effective visualisation systems: From Table 3, it could be seen that display system (GS6) and display system (Data Sign C5) together meets the functional requirements of traffic management system. However the integrated communication requirement related to establishing communication between visualisation system and the rest of traffic management system have not been thoroughly supported by any of available display systems. Therefore, there is a requirement of developing a Composite Visualisation System that not only meets functional requirements but also provides the required communication interfaces. The GS6 and data sign C5 systems are used and the same are integrated through a separately selected embedded board which is provided with all the required communication interfaces so that the visualisation can be made to be addressed by using any of communication means. Figure 3 shows the hardware interfacing of the display board and the communication interface boards. GS6, DATA SIGN C5 and automatic display adjustment system are used for affecting the required displays. These display systems are interconnected with Raspberry PI board. Data sensed by various sensors installed at different locations alongside the traffic route are transmitted to the Raspberry board using different communication systems the interfaces for which are supported on the board. The communication is effected as shown in Fig. 4 using either the Wi-Fi, cellular or satellite communication interfaces.

These sensed values are sent to the Raspberry pi board which processes these signals and digitizes them further using different conversions. Then the converted signals are further sent to the control stations using on-board Wi-Fi and Bluetooth technology. The kind of communication interface used is dependent on whether data is being received via a signal post system when is generally local and situated within distance of around 1000 meters or a local base station or from remotely situated traffic monitoring controlling station. GS6 Display Board is used fordisplaying videos and is used for remote access and automatic monitoring. The DATASIGN-C5 can display any range of messages composed of letters, symbols and animations in 5 different high visibility colours. The DATASIGN-C5 is a must for efficient local traffic management, roadwork safety and is a very effective advertising tool. Cellular interface is used for effecting communication from base stations, satellite communication is used for effecting communication from remote locations to visualisation system and Wi-Fi communication system is used for effacing communication between signal post system and visualisation systems.

HDMI (High-Definition Multimedia Interface) is an audio or video interface to transfer un-compressedvideodata and to transfer compressed or uncompressed digital audio data from an HDMI compliant source device such as a display controller, to a compatible computer, video projector, digital television or digital audio device.

CONCLUSION

Improving the efficiency of Traffic Management Systems is still an active and challenging research area due to the criticality of the transportation infrastructure being monitored by such systems. This study has provided a comprehensive study of visualisation systems for modern Traffic Management Systems, emphasizing the main challenges and short comings of the existing systems and suggesting some directions to make the Traffic Management Systems more efficient in future smart cities. The integrated composite visualisation system presented in this study supports of all the functional requirements of the system.

REFERENCES

Chen, W., F. Guo and F.Y. Wang, 2015. A survey of traffic data visualization. IEEE. Trans. Intell. Transp. Syst., 16: 2970-2984.

DOT., 2010. Introduction to Variable Message Signs. Student Handbook, Washington, USA., Pages: 58.

Imawan, A. and J. Kwon, 2015. A timeline visualization system for road traffic big data. Proceedings of the 2015 IEEE International Conference on Big Data (Big Data), October 29- November 1, 2015, IEEE, Busan, South Korea, ISBN:978-1-4799-9926-2, pp: 2928-2929.

Lu, C.T., A.P. Boedihardjo and J. Zheng, 2006. Aitvs: Advanced interactive traffic visualization system. Proceedings of the 22nd International Conference on Data Engineering (ICDE'06), April 3-7, 2006, IEEE, Blacksburg, Virginia, ISBN:0-7695-2570-9, pp: 167-167.

Walton, S., 2016. Real-time traffic video visualisation on geographical maps. Apache Solr. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.472.6886.