

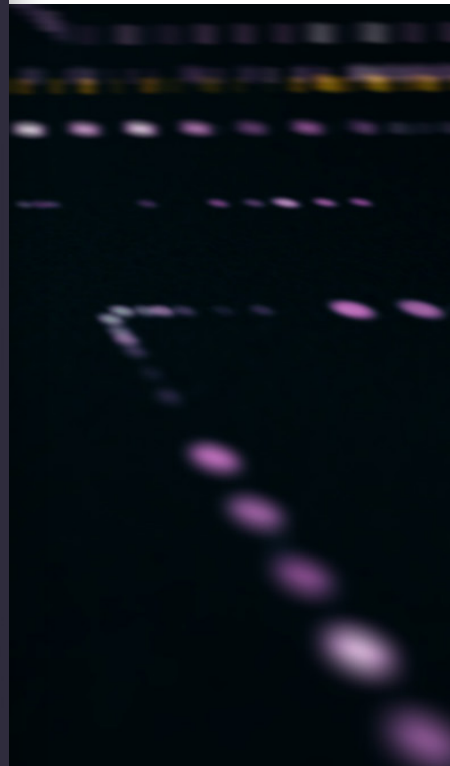


IMMERSIVE DATA VISUALIZATION FOR SMART CITIES

BRINGING DATA TO LIFE FOR BETTER GOVERNANCE

By Jan-Philipp Mohr

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Smart cities uses immersive data
visualization for data-driven governance and
timely decision making





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ABOUT THE WHITE PAPER

This white paper provides essential information about how immersive data visualization can make smart cities truly smart.

TOPICS INCLUDE:

- An overview of growing importance of big data and increasing complexity due to multi-dimensionality of data
 - Need of a right visualisation technology for city administrators
- Benefits of immersive data visualizations for making decisions for governance and economic growth

EXECUTIVE SUMMARY

Today, half of the world lives in cities; the proportion may grow two-third by 2025. The urbanization brings prosperity to the nations. However, if they are envisioned and managed well, they become source of miseries. Let's take an example of roads and highways of the U.S. Today, the average American worker spend 20% more time commuting than they were in 1980. Government statistics reveal that more than 38,000 died in the road accidents around 4.4 million injured only in 2015. The economic cost of those tragedies has been estimated to be \$152 billion. Emotional cost? Ask windows who have lost their husbands, or mothers whose only child died there. The situation is also grim for bridges in the U.S. Out of around 600,700 bridges, 20,000 have been declared fracture critical. It means if you have travelled on those bridges recently and still alive or not hurt, you are just fortunate.

Problems ask for solutions. In the search for solutions, the cities are aiming to become smart by connecting the isolate systems of civic bodies and installing intelligent sensors. City administrators aim to harness insights from the data from the Internet of Things (IoT) sensors and external data. However, the always-on, always-watching world of smart cities now generates an enormous amount of data that current data analytics solutions fail visualize insights in a way human minds can understand easily.

You have invested millions of dollars to get billions of data points. But, now you still need to waste days to discover which "ABC" bridge needs to be repaired first. And, by the time you initiate actions, the bridge has already fallen. Lives lost. Often, the data analysis software are so complex that you cannot do the analysis

by yourself. You depend on data scientists to give insights. They take their own time as they, too, are humans and have the same software. Fortunately, they don't have any direct accountability to the people but you have.

You need to create a vision for your city's future, estimate the budget for infrastructural developments and take decisions on taxes and revenue over to meet costs. You have responsibility to create a healthy environment where residents are safe, and businesses thrive. For all these, you need a reliable tool for decision making that helps you see a big picture and allows you to drill down for a root cause analysis of a situation.

Immersive Data Visualization, which leverages the power of virtual reality, augmented reality, game engines, machine learning and GPU computing, is an ideal platform to visualize streaming IoT data. Its natural gesture-based visualization not only intuitive but it also able to show complex spatial and temporal data on the virtual replica of an environment, say Google Earth model or a city's 3D prototype, that you are already familiar of. The new technology releases you from two-dimensional flat screen data cages, and lets you step into your data itself helping you discover insights with a simplistic yet very powerful way of visual correlation.

Simples, it does not pain to make decisions with the immersive data visualization.



VISUALIZING BIG DATA FOR BIG CITIES - A TASK EASIER SAID THAN DONE!

The Need of Smart Cities for a Sustainable Future

50% of the global population lives in cities, and it is growing by 2% every year.¹ Large cities are struggling today to generate sustainable economic opportunities for their citizens, meet their infrastructural needs, and, most importantly, provide public safety to them. Local governments are looking at digital technologies, the Internet of Things (IoT) and green energy to build smart cities for overcoming these challenges. They are installing sensors in their urban systems such as transport, law enforcing agencies, and utilities to connect them and let them talk to each other to solve urban miseries. For example, in cities, people create 30% of traffic while looking for a parking space. An integrated urban information system available for citizens to use it on their mobile phone can easily solve this problem. Cities use 70% of the world's energy; 20% of usage is lighting. Cities can use LED lighting with an algorithm to manage it efficiently to cut energy consumption by 50% to 75%.² The opportunities are unlimited for governing a

British Standards Institute defines a city is smart when it displays effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens.

city in better way and saving million of dollars for building a new future.

However, sometimes, evolving smart cities fail to meet people's expectations. There are still leakages in water pipes, terrorists still attack innocent people, and streets still get congested with a rising number of vehicles, that too, in megacities such as New York and London. Critics call smart cities a digital chaos, not a solution, where ugly uses camera and sensors are monitoring them every nook and corner of their cities and compromising their privacy without making any significant impact their lives.

These failures, say terrorist attacks, are sometimes too advanced for current technologies to predict, but most of the times, the letdowns are just missed opportunities to use the power of data. Smart cities are built on data. Connecting the systems and storing data is one part and generating actionable insights from the data is another part. For smart cities, becoming a chaotic proposition from a futuristic solution depends on how intuitively stakeholders find a pattern and how easily understand insights to make faster decisions to solve people's agonies.

Can we let failures to make sense out of data become a curse for smart cities?

CHALLENGES IN MAKING SENSE OUT THE DATA FOR SMART CITIES

An Ideal Data Visualization and Discovery Platform

Enormous amount of data, or big data, generated from camera, sensors, global positioning systems (GPS) devices, smartphones and computers is moving in information supply chains of cities. We use sophisticated tools to process these data – 80% of these data is dark data, meaning, data is unstructured to convey any meaning by itself. We visualize the processed data to uncover the patterns to decide next steps. In order to make this process effective and avoid any analysis-paralysis situations, it is extremely important that the decision makers, in the current context, non-tech savvy city administrators, can visualize, and interact with the data and find out hidden pattern by themselves. It means we need remove the dependency on data experts from the loop, which in turn means that the data discovery and visualization platform must be awfully intuitive to interact with data and insights become visually obvious in the discovery process.

The data visualization comes at the end of big data value chain. Like big data, it also deals with three Vs -volume, velocity and variety.

- **Volume** is linked to number of objects to be visualized at the same time. Typically, more objects result in better models and predictions. Since, in smart cities, we get spatial data, visualization them on spatial on a map or a virtual 3D copy of city is important for an intuitive understanding.
- **Velocity** or speed is critical in data visualization as data is temporal in nature and different objects have different lifespan. Temporal grouping and visualization is highly recommended to reduce the data noise.
- **Variety** is another factor in the data visualization. Data is coming from different source, all sources have different format and structure such as short, incomplete text from social media and ambiguous data from weather or pollution monitoring sensors. A powerful lexicon analysis will result in actionable data in a given context.



Data Visualization Challenges

Unfortunately, city administrators are able to use the much of data generated by connected devices due to inherent complexities in the data and the lack of a centralized repository based on a sound data governance framework. Moreover, the data that gets analyzed is not of much use as its visualization and rigidity often bewilders stakeholders and ultimately, they get so scared of these systems that they stop using them. The data-driven decision making for a better governance becomes an elusive dream and a catch-22 situation.

Below are some major challenges faced stakeholders in data analysis and visualization with today's popular solutions:

- **Lack of ability to handle diverse types of data:** The visualization platforms lack ability to integrate a large volume of static data (e.g., geographic maps) and dynamic data (e.g., sensor data and live social feeds), then process and visualize them. Even, if they do, outputs are more a confusion than insight.
- **Lack of ability to visualize spatial and temporal data:** Data visualize without spatial and temporal knowledge give zero context and makes decision making process more obscure. Current visualization platforms do not visualize data (e.g., traffic data or parking space) on a platform (e.g. Google Earth Model or city's 3D virtual imagery) that decision makers can intuitively understand. The visualization on 2D screen becomes a clutter or data delusion.
- **Limited field of view of objects:** Multi-

dimensional data (e.g., vehicular traffic data) cannot be probed effectively from different aspects (queries such as "when was traffic data highest" or "How is it related to weather?," etc.) on a flat screen. To understand their different facets and relations with other data, you need to run analysis multiple times. You, often, forget the previous relations or you do not get a complete picture of a situation simultaneously.

- **Lack of real-time data dissemination:** Imagine there is a leakage with a pipeline at a locality A. A new engineer goes there and want to dig the ground. He must rely on a 2D static map without any detailed information of equipment installed underneath. If he needs any help for his senior and rely on voice-based instructions. Though the sensor captures all information about the pipeline and availability of smartphones, the current platform fails to disseminate critical information to remote workers.

- **Lack of Features Enabling Collaboration:** The current analysis and visualization platforms do encourage collaboration as stakeholders from different departments such as water and waste management departments from remote locations cannot see and interact the same data simultaneously.

Today, cities move by data. Government agencies prevent unwanted incidents, warns citizens beforehand any eventualities and protect them using real-time data insights. **Any inefficiencies to handle data not only make the smart cities ineffective but also pose severe risks to citizens' lives.**

Thankfully, technology companies like Hashplay have come with innovative immersive data visualization platforms to solve these challenges.

THE IMMERSIVE WAY VISUALIZATION SMART CITY DATA

The immersive data visualization uses power of virtual and augmented reality, cognitive computing and cloud technology to make the pattern discovery process intuitive and contents easily consumable by decision makers without any data overload.

Virtual reality (VR) allows users to immerse themselves in a virtual or digital world while augmented reality (AR) overlays digital images on the physical world. The hybrid reality or mixed reality (MR) merge physical and virtual worlds to generate a new visualization where both world coexist and interact in real time. We will call them together as an advanced reality or immersive visualization for our easy reference.

The advanced reality data visualization and smart city are a match made in heaven. The smart city, powered by IoT data, strives to improve the quality of lives it citizens whereas advanced reality platform uses IoT data to make smart cities truly smart enabling its stakeholders to make right decisions in real time. The VR and AR bring data visualization brings analysis experience to life.

Below are the key highlights of Immersive Data Visualization Platforms:

- **Built for IoT Streaming Data:** Using game engines, VR and AR data visualization platforms are able to show multiple objects and update their states at several frames per second (FPS). They use graphical process unit (GPU) computing to enhance speed of data processing for streaming IoT data.
- **Visual Correlation for Pattern Discovery:** Correlation is very important to understand contextual intelligence. Without a visual correlation, you will end up with huge of dump of data providing insights in parts. You will lose the vision. You may fast run, but you end up going nowhere. The IDV brings intimate knowledge of performance your cities in a sum-of-parts way. A single gesture or touch will help you drill down to get more data around the health of department or system, thus enabling you to the root cause analysis in seconds. The correlated view provides the contextual and the exact amount of information that you need.
- **As Many Dashboards as You Want:** IDV allows you to analyze the situation side-by-side and spot anomalies. You are no longer constraint with one screen or two screens. You can create as many dashboards and as big as you want to see in a single view. It also enables you to overlay information on the same dashboard or chart to get impact analysis of changing parameters. One dashboard can give you economic impact, other can give you operational benefits and other dashboard can give you the impact of social impacts.
- **Situational Awareness in Real Time:** Situational Awareness (SA) is extremely important to govern a city. Situational Awareness is driven by power of the w3 premise – what, when and where. In the context of smart cities, it means our ability to identify, process and comprehend the data that deals with safe
- **Enhanced Comprehension of Reality:** Advanced reality visualizes models using spatial and temporal datasets (e.g., traffic



data, water supply and weather data) with a high resolution on a digital twin of a city making insight comprehension really easy. It uses spatial division of data based on their latitude and longitude and relevant temporal grouping data to visualize on digital maps with a timeline.

- **360-degree View of Data for Faster Pattern Discovery:** It provides 360-degree view of objects and interactive simulations enabling city administrators solve uncertainties with different planning scenarios.
- **Experiential Data Analysis:** Since you immerse into the data and interact with them

using natural gesture-based controls, the visualization takes become experiential and intuitive for supporting high-end analytical tasks. VR and AR animate 3D objects which makes the identification of repetitive behavior more recognizable than traditional 2D/3D histograms.

- **See What You Want, No Clutter:** In the advance reality, you can overlay numerical values from hundreds of sensors simultaneously on visualized objects whenever you need. The platform is free from visual clutter and gives insights that are important to you.

SMART CITIES ARE MAKING SMARTER DECISIONS USING THE IMMERSIVE DATA VISUALIZATION

When cities become popular, the legacy existing infrastructure fails to sustain continued growth and improve the experience of citizens. Businesses and residents struggle to get even basic amenities like water and electricity. Smart cities are using predictive analytics and immersive data visualization to design, build, check and improve cities' infrastructure. Using live-stream analysis, visual analytics and text mining, the advanced reality platform process millions of data per second and represent insights on dynamic dashboards to enable local governments to act on real-time insights of evolving situations. The advanced visualization platform connects data from all urban systems to create a centralized repository in cloud without changing anything in their legacy. It is very fast and cost-effective

solution to implement to create a data-driven city management system.

This visual intelligence platform is enabling city administrators to a range of mission-critical operations enriching and saving lives of millions of people inhabiting their city.

Smart Transport and Highway Management

The immersive data visualization platform displays traffic data on a city's digital imagery and provides interactive simulations to predict unfolding situations to ease traffic congestions. IDV helps you to understand

pattern from the real-time data as well as historical data such as accidents, driving under the influence (DUI) arrests, weather, sporting events and parades to help you manage traffic congestion and minimize accidents. Enabled by sensors, street signs, traffic lights and even building communicate with each other. The street signs can be changed, the duration of traffic light can be changed and send alerts to drivers regarding a better route.

By using predictive analytics, law enforcement agencies can know areas with high probability of accident dynamically before they occur to prevent accidents altogether or plan assistance in case of an emergency. For example, if there is an accident, the system should send alerts to police, ambulance stations, call centers and toll gates so that disruptions due to the accident could be managed. The Tennessee Highway Patrol is leveraging a software called Crash Reduction Analyzing Statistical History (CRASH) that analyze data pertaining to crash history, sports events, location of alcohol shops, and weather among other variable to predict where accidents can happen. Though the system was still developing, the officials claimed that its accuracy was 72 percent and helped them bring down the accidents by more than 5 percent.³

Israel is also using the power of data to manage congestion. It focuses on the economics of matching demand with supply. It has introduced a 13-mile fast lane on Highway 1 between Tel Aviv and Ben Gurion Airport. The toll uses a dynamic pricing for fees based on the traffic density. The pricing impacts the affordability of the route when demand is high. It uses the number of the cars traveling on the route, space between them car (using real-time pattern recognition) and the amount of the traffic the road can bear.

The transport department needs to optimize the entire system and needs to have a view as a whole: cars, buses, trains, bikes and pedestrians. If the agency sees people are using cars when they could use trains, they need to understand why and plan strategies to move people from private transportation to public transportation. One way could be them fare discount.

The city of San Diego uses data analytics to cut down fare evasion and to know where commuters are going by reading smart cards on its buses and rail systems. They also use this data to build infrastructure such as a new road or transit stop.⁴

The biggest benefit of IDV is that it lets you see get the big picture from the billions of data points.



The VR and AR can be made to existing software, and data can be visualizing using the software, say a third-party map and city's 3D designs as well as own GIS maps.

IDV links the systems to let you visualize the entire impact and a big picture of your city. For example, you increase fees for a toll for a route, it will show its impact on the congestion reduction of the route, the extra money that you will earn and where you can invest the



money to manage the congestion in future.

IDV enables cities to better lives of their residents by giving a holistic view of entire city by connecting, simplifying and visualizing data from isolated systems in a way that it is easier for our human mind to plan the future well.

Usually, once infrastructure projects, say highway, are build, their maintenance and repair are less emphasized. However, erratic weather conditions such as temperature and storms rise many implications for roads, many times, posing the risk of disruptions and failure of entire transport system. Today with help of data analytics and immersive visualization techniques, we can study the parameters and the correlations that are critical to the infrastructure deterioration.

The construction companies should know what material have been used previously and what new standards need to be followed now. There are high costs of connecting and aggregating data. Do let your investment fall because of its sub-optimal use. More data means more accurate prediction, more accurate journey towards maximizing the welfare of your residents.

Smart Healthcare

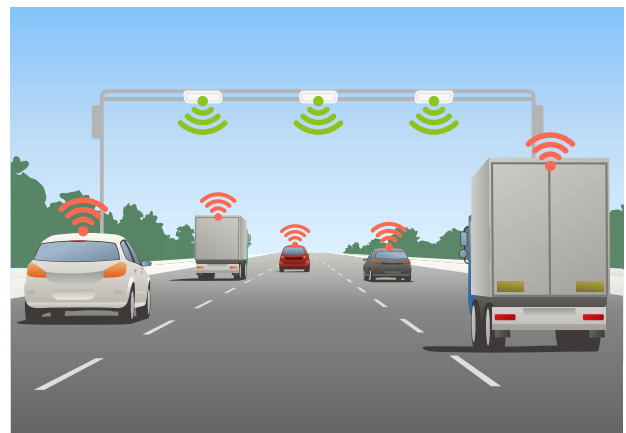
Real-time data from hospitals, grocery stores, insurance companies and census data can be fed into VR and AR applications to generate insights on citizen's health by location, different demographic parameters and season. The data can be used to understand the correlations among variables and an effective healthcare scheme can be formalized.

The average American worker spends 20% more time commuting today than they did in 1980.⁵

38,300 people died and 4.4 million injured on the U.S. roads in 2015. The related economic costs were estimated to be \$152 billion.⁶ There are 607,000 bridges in the U.S. Around 65,000 are classified as "structurally deficient" and 20,000 as "fracture critical." It means severe tragedy could have happen any time. We need to prioritize the repairs and maintenance. Data from sensors can help in prioritizing.⁷

The painful commuting pressure businesses and residents to relocate, directly impacting the economy of a city.

The correlation among weather conditions, speed of vehicles, light conditions and driver's responses can be analyzed to find out the reasons of accidents.



The VR and AR visualizations help the pattern recovery fast on a city map. The immersive data visualization very useful while stopping an epidemic. Data overlaid on hospitals and clinics on different locations can provide insights on and behavior of people affecting their health living around them.

Smart Energy

Energy management is a top priority for all governments around the world. Growing popularity of concepts such as green buildings need no explanation. Smart cities are using data to encourage home and business users to conserve energy, use renewable sources and manage peak demands. With smart metering and 3D geospatial data, the VR/AR applications can perform visual energy analysis for an apartment, a building, a neighborhood or a city in seconds. The city governments can use insights to devise their energy conservation strategy. They can feed new data, say costs of newer intelligent street lighting systems, into the application to check a cost-benefits analysis of the investment to take go/no-go decisions.

City's energy companies are pairing of IoT and augmented reality-enabled application for predictive maintenance and optimizes energy consumption by their equipment.

Smart Water

Out of sight is out of mind. This holds true especially for aging underground pipes in most of major metropolitan cities around the world. For example, water main breaks in the United States from Syracuse to Los Angeles, is 240,000 per year⁸ and the direct cost of these leaks is estimated to be \$2.6 billion per annum.⁹ However, the unaware governments have declining spends in water infrastructure. Under the smart city initiatives, the governments are installing sensors to

monitor the health of water pipelines. The immersive data visualization can display data on the network of these pipelines and predict maintenance requirements or any other issues related to their stakeholders proactively.



Smart Police

The use of data analytics and visualization to detecting and containing crimes is not something new. London, Los Angeles, Chicago and Amsterdam have been leveraging predictive analytics to reduce crime rates for years. However, the VR and AR visualizations make repeatable pattern of criminals more obvious by visualizing the key facts on the virtual map and timeliness. The immersive data visualization enables the exploration of data from multiple dimensions to identify provide characteristics of criminals or locations and crime rates. Social feeds are also being analyzed to identify terror attacks occurrence. Though, not everything can be predicted, however, the insights are useful to manage crimes. In many cases, the crime rates come down just by deploying police at the right time at right locations, without making arrests.

Smart First Responder

Using live data feeds from sensors and social media, the immersive visualization helps first responders control incidents. They can manipulate variables to see the prediction of events. They could visualize where the crowds behave during a storm or fire, or how the fire will expand in a specific location. The AR can also enable first responders to manage hazardous material (radioactive material) with live data in front of them, providing steps to deal it in a clear, easy-to-understand way.

Smart Planning and Budgeting

The immersive data platform can provide an aerial view of the city with vital financial and operational information such as population, water in a tank, traffic movement and weather conditions. The AR applications can overlay more information for a building such as dimensions, engineering specification, building materials, energy usage, number of residents and parking spaces when you zoom on it. The urban planning has become immersive and collaborative; any department, say the waste management department, can use these information for planning right infrastructure to meet the resident's need. The centralized and easy-to-visualize data enable stakeholders to decide where the public money would have the maximum impact and what work would be most adequate for citizens.



SMART VISUALIZATION IS THE FIRST STEP TOWARD BECOMING **A TRULY SMART CITY**

The applications for analytics-infused virtual or augmented reality are as limitless and only limited by our creativity. Today, often, in our democracies, stakeholders describe the same things in different ways creating confusion and blocking the progressive decisions. The immersive data visualization helps create a participatory, more evidence-based, more agile, more democratic decision-making platform. The combination of analytics and AR/VR will allow them to tackle new and existing challenges in a more informed and efficient manner, ultimately saving money, time and maybe even lives.

In the end, the data visualization and analytics is not just about gathering information and generating report. It is about enabling governments to create a better place for citizens to live and work. Without a well-defined vision and right platforms, governments will be lost in data and make cities more chaotic than they already are.

With Immersive Data, the innovative immersive data visualization platform powered artificial intelligence, cognitive computing and cloud computing, Hashplay works collaboratively with city time-pressured city administrators to understand their purpose, key objectives, main challenges and immediate priorities to develop a decision-making platform that enables them in real sense. We understand they are juggling with multiple responsibilities and need real insights to make right decision. This is all about "Immersive Data."

**AUTHOR**

Jan-Philipp Mohr - Founder, and CEO, Hashplay
jpm@hashplay.tv

Jan-Philipp along with Ingo Nadler and Jan Schlüter founded **Hashplay Inc** in 2015. He also co-founded an on-premise big data solution for retailers that lets users choose wines matching their taste and personality with a unique algorithm. Before, he successfully advised Family Offices on their high-tech & media M&A.

Contributors

Jan Schluter - COO, Hashplay
js@hashplay.tv

Ingo Nadler - CTO, Hashplay
in@hashplay.tv

Abhishek Pandey - Research Lead, Hashplay
ap@hashplay.tv

ABOUT HASHPLAY

Based out of San Francisco, Hashplay Inc. an Advanced Reality software company that has developed the ultimate Visual Data Intelligence Platform - ImmersiveData. Hashplay's GPU powered analytics platform brings operational intelligence, business intelligence and situational awareness with real-time data to one place enabling enterprise act fast and foster collaborative innovation.

ImmersiveData® enables organizations to qualify, unify and visualize both, real-time and legacy data, merge geospatial, CAD, and technical models, along with workflows and operational data to give managers the ability to make better and more informed decisions.

Hashplay serves clients' needs in Oil & Gas, IoT, smart factory and smart city.

LEARN MORE:

To learn more about immersive data visualization or request for a demo of Immersive Data, please contact:

Jan Schlüter
Direct line Europe: +49 (171) 522 1520
Direct line US: +1 (650) 488 5227
js@hashplay.tv

Hashplay Inc
350 Townsend #755
San Francisco, 94107, CA
United States

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