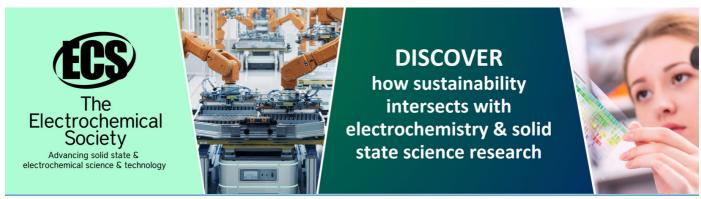# Digital Earth: the next paradigm

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Digital Earth: the next paradigm

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Abstract. Digital Earth technologies [1] collate rich information about the physical world around us from sensors to create digital twins. Digital Twins integrate multi-dimensional geometric representations, internet of things, artificial intelligence (AI) and analytics. Graph based digital threads trace all lifecycle transactions and associations to ensure the integrity of this cyber-physical coupling. Through metaphors such as virtual globes we can apply this framework to build a deeper and more collaborative understanding of the complex dynamic interactions in our physical world and what bearing these may have on our wellbeing.

Introduction

Evolution towards a Digital Earth will be neither gentle nor gradual, but a serially disruptive sequence of punctuated equilibria [2]. The emergence of this new digital twin landscape will be supported by the rapid co-evolution of technologies, digital content, rich formats, graph models, and new legal and policy frameworks. Connected and Autonomous Vehicles (CAV) provides us with an early insight into the way a Digital Earth is evolving as a complex adaptive system and how it may shape our collective consciousness and serve us as a critical 'super-sense' for survival.

Scalable Patterns

CAVs are equipped with a combination of sensors such as cameras, LiDAR, GPS, IMU, and radars [3]. These sensors help in providing redundancy should any of the sensors fail. Full automation of driverless vehicles requires multi-modal gathering of spatial intelligence to identify and classify objects in real-time and instigate an appropriate navigational course of action. The need for machine-human interaction in tactical manoeuvring lessens as the capability steps up from partial, to conditional to full autonomous automation.

There is no margin for error so comprehensive base maps with support for geometric, semantic, behavioural and other contextual (including weather) data provide a critical spatial and topological knowledge base required to support the CAV's onboard 3D mapping-on-the-fly capabilities. These High Definition (HD) maps need sub-5cm precision and are being developed to overcome sensory limitations and provide these robots with a comprehensive digital twin of the immediate world at a 1:1 scale.

The next horizon will arise with advances in interconnectivity enabling vehicles to communicate and choreograph with one another while also anticipating behavioural and physical impediments in real-time. Beyond this scenario, a more sentient network will evolve to re-route traffic and optimise utilisation of assets. In this new paradigm our current supply-side notion of road access pivots to a performance-driven demand side paradigm.

Digital Earth as a Human Super-sense

We perceive the world through our natural senses. These evolved to make us aware of our environment and have been essential for our survival. As we enter the Anthropocene epoch these natural senses will need augmentation if humanity is to survive. Like our natural senses this Digital Earth 'super sense' increases our cognitive awareness of the world around us and informs our decision making by revealing the marvellous complexity about the places we live and care about. It builds biographies of places and helps us to discover the and share the deep stories about these places. It is a knowledge amplifier providing us with unprecedented insight into what enables our planet to support life and opens our minds to potential opportunities to improve our stewardship. It makes the intangible tangible, the invisible visible and gains us valuable insight into climate change and patterns that translate into better warning and response times for dangerous weather events, pandemics, earthquakes and other disasters.

Through Digital Earth as a collaborative 'commons' participating nations can accelerate their knowledge economies and improve the lives of people in this and future generations all around the world. With the metropolitisation of the global economies, cities have become more relevant to our liveability than nations [4]. Digital Earth's evolution will provide us with rich topological associations between events, places and people. These topological associations will challenge our spatially bound notions of nationhood. As we have witnessed with the Internet, new social subcultures and forms of digital tribalism will be born.

With unprecedented scientific rigour, a Digital Earth will help to ensure more transparent evidence-based planning. For data journalists and artists, a Digital Earth [5] will serve as an 'ultimate' source of truth and frame our expression of places, events and our self-identity. A Digital Earth will underpin ethical AI and become, like HD Maps are to CAVs, the ultimate reference of truth for future moral machines.

Digital Earth on a common continuum with the Human Genome Project

An expanded global initiative, supported by shared and accessible technologies, to enable people to collaborate, apply their knowledge and use it creatively to make decisions, address issues that concern them and participate in sustainable economic activity would underpin the advanced scientific enterprise. One aim of such a project would be that the value of a richer understanding of the physical aspects of the planet, and its complex systems, is recognised by most people and enriched by parallel insights, understanding and evolution of the social and cultural aspects of a widely shared human consciousness. Digital Earth is the digital twin of the dynamic complex adaptive system that we have evolved into and are part of. As a big science, this project is magnitudes in both spatial and temporal scales beyond the scope of the Human Genome. Like the Human Genome project before it, a priority should be given to the non-technology based aspects – the ethical, legal, and social issues that will be created by the onset of the project. In these challenging and uncertain times there is a compelling necessity and exciting potential for Digital Earth as a knowledge amplifier for ensuring the safe wellbeing of humanity and our planet. A Digital Earth should become the definitive scientific and technical achievement of the 21st Century.

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