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An overview, examples, and impacts offered by Emerging Services and Analytics in Cloud Computing virtual reality

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Abstract This paper presents a high-level overview of Emerging Services and Analytics in Cloud Computing virtual reality including the rationale, technologies involved, selected examples, and contributions. Examples in health care, business, climate change, and natural disaster have been demonstrated to support Emerging Services and Analytics by virtual reality, which can allow scientists to understand the complexity behind science and process thousands of data within seconds. Not only scientists with deep knowledge but also the general public can understand part of the outputs and illustrations from different types of examples and outputs from other disciplines. Businesses can achieve business agility, improvement in efficiency, monitoring the daily work, and analyzing key performance indicators up to date and in real time. We present the case of Emerging Services and Analytics by virtual reality to discuss its contributions and future directions.

Keywords Cloud computing virtual reality · Emerging services and analytics by virtual reality · Academic proposals for organizational and industrial adoption

1 Introduction

Rheingold [1] defined the term virtual reality and gave examples that simulations and services can be delivered in the emerging technologies. Steuer [2] further expanded the concept and developed a dimensional approach to determine its presence. More emphasis has been paid attention to for electronic media, whereby Ryan [3] emphasized on interactivity as a core element in virtual reality, so that user experience can play an influential role. Zyda [4] continued to expand Ryan's concept by demonstrating how to make visual simulation and implement it in virtual games, so that users can understand complexities incurred in real life, which can be simulated many times by virtual games. Biocca and Levy [5] investigated the up-to-date ways to make virtual reality happen with the most convenient, cost-effective, and popular ways adopted by users. One of the suggested ways is to deliver virtual reality by Cloud Computing, since it is fast, convenient, and effective. Virtual reality by Software as a Service (SaaS) is a common way to deliver virtual reality [5, 6]. However, there is little research to investigate the links between virtual reality by Cloud Computing, ways to deliver SaaS, and selection of successful examples.

Dated back in 2007, Cloud Computing was considered a new territory, an unknown area, a buzz word, and a representation of advanced technologies, new services, business opportunities, and marketing strategies. Cloud Computing means different perspectives to different people leading to different interpretations. In general, Cloud Computing is divided into three services: Infrastructure as a Service (IaaS), Platform as a Service, and Software as a Service (SaaS) [6, 7]. It has four types of Cloud: Public Clouds for the general public to buy and access from service providers such as Amazon; Private Clouds that organizations build for their own employees to use; Hybrid Clouds that blend and use both Private and Public Clouds; and Community Clouds based on the membership and development of research or enterprise communities with similar interests [6, 8]. There are different types of studies, research outputs, demonstrations, and services on Cloud Computing, as follows. Marston et al. [7] define the business perspective for Cloud Computing and explain in detail the definitions of Cloud Computing, how Cloud

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Computing can be used, and its impacts to businesses with selected case studies. Weinhardt et al. [9] describe their service level for Cloud Computing and assert that Cloud Computing can be used as a new service computing to provide effectiveness for organizations. Sultan [10] presents his case that Cloud Computing can be useful for education which has been supported by researchers that demonstrate education as a service supported by different case studies [11, 12]. For example, the adoption of Cloud Computing has provided benefits to the University of Greenwich with improvement in student satisfaction and the University of Southampton which achieved cost savings. Sultan [13] explains the significance of Cloud Computing for the Healthcare sector, whereby the National Health Service (NHS) plays an influential role in the development of Cloud Computing services. Sultan [13] describes case studies in the NHS Hospitals in the use of Cloud Computing services and concludes the benefits of Cloud Computing adoption. Framework approaches are commonly used in evaluating the effectiveness of Cloud Computing adoption. Chang et al. [14] describe the development that leads to a Cloud Computing Business Framework (CCBF) and explain the benefits of Cloud Computing adoption, as well as the need for organizations to achieve different goals and requirements. They explain how four different components in the framework can connect together to further establish into a robust and validated framework supported by their case studies developed for each component. Gupta et al. [15] survey on SMEs in Singapore, Malaysia, and India and investigate factors for Cloud Computing adoption in cost reduction, reliability, ease of use, collaboration, and security. Hsu et al. [16] conduct large-scale surveys based on their TOE framework, collect data, and analyze how Cloud Computing has been used and perceived in Taiwanese SMEs by their multiple regressions. Results from Gupta et al. [15] and Hsu et al. [16] have largely supported their hypotheses to demonstrate that Cloud Computing can be useful for adoption.

Foster et al. [17] explain the scientific problems faced by Grid Computing which are similar to that by Cloud Computing. Even so, there are no follow-ups since this paper. This may mean additional work is required to fill in the gap and meet challenges of Cloud Computing adoption such as security, performance, data ownership, and bottlenecks of Cloud Computing described by Ambrust et al. [18]. Buyya et al. [19] illustrate that Cloud Computing can be the fifth utility to provide greater impacts to the day-to-day life. To further extend their rationale, Buyya et al. [6] demonstrate that quality as a service (QoS) is important for Cloud Computing users since the services on offer could affect pricing model, costs, effectiveness of conducting experiments, and the experience of using services. With their research and development outputs, CloudSim and Aneka have been published at different periods of time. CloudSim is a Java-based open-source software to simulate the use of Cloud Computing located at different data centers. Developers and users can study the energy consumptions, costs, QoS, and management of data centers and calculate the costs involved. Aneka is a .Net-based software to allow scientists and organizations to support multiple application environments, rapid development of frameworks, and provision of Cloud, Grid, and multi-core services [20]. Contributions from Buyya et al. [6, 19] and Vecchiola et al. [20] demonstrate that there are increasing needs for businesses and individuals requesting better quality of services, integrations with other technologies, and easy-to-use approaches for service development, since businesses may find it undesirable to spend time to fix new and ongoing problems and may need Cloud Computing services to provide them the edge of competitiveness by delivering their services faster and better with lower costs and more outputs. One example to consolidate this trend is the use of analytics and visualization such as the use of Big Data services [21]. Analytics and visualization are designed to intelligently compute mathematical modeling and simulations behind the scenes and transform the complex data and numerical inputs into outputs that have better appeals and better ways to understand and interact, including graphs, reporting systems, and gadgets [22–24]. Analytics and visualization can be used in business intelligence, whereby the stock market indexes for major stock can be computed and monitored every second. The analytics services can calculate the risk and return of buying and selling assets in each second [25]. All these new services have been developed beyond their original designs and capabilities to offer services better, faster, and more seamlessly and integrated with other services. It can be classified under the Emerging Services and Analytics category since they provide the latest cutting edge technology and advanced techniques to make all these services technically challenging and easy to use at the same time [26]. The role of virtual reality is fully relevant to the development of Emerging Services and Analytics, since visualization techniques and 3D or multi-dimensional computing technologies are required to make simulations more lively and accurate. Emerging Services and Analytics can be served as the next generation of virtual reality enabled by Cloud Computing and SaaS technologies.

All the examples described in the last paragraph can explain the rise and the need of Emerging Services and Analytics by virtual reality, which are aimed to process complex data behind the scene and present outputs that allow the stakeholders and the general public to understand with ease. Emerging Services and Analytics by virtual reality provide new forms of services which can be presented to analysts, directors, and customers in different ways. It offers business opportunities since it includes applications and services for customer relationship management (CRM), supply chain management (SCM), risk analysis, price and risk forecasting, and business and accounting services. Emerging Service and Analytics require the use of Cloud Computing, Big Data,

security, intelligent systems, and web technologies to jointly deliver a wide variety of services in multiple domains such as health care, finance, education, mobile services, transportation, energy, natural science, and physical science as demonstrated by the successful running and deliveries of international workshops in 2014 and 2015 [26, 27] and then an international conference on Internet of Things and Big Data in 2016.

This paper is aimed to discuss Emerging Services and Analytics enabled by virtual reality focused on 3D and Visualization advanced techniques, as well as its positive impacts for people and society. Scientific work involved with earth science and natural disaster can be illustrated by virtual reality, since it is significant to highlight issues raised by the awareness of climate change and investigation of alternative solutions dealing with natural disasters. The use of Emerging Services and Analytics by virtual reality can investigate complex science and achieve low costs at the same time. To demonstrate contributions and significance, the breakdown of the paper is as follows. Section 2 narrates the overview of Emerging Services by virtual reality including technologies involved and the differences Emerging Services can make. Section 3 describes the Emerging Services and Analytics by virtual reality for climate change, which includes sandstorm simulations, clash of air pressures, and temperature distributions of selected countries. Section 4 presents the Emerging Services and Analytics by virtual reality for natural disasters, including seismic simulations and tsunami simulations. Section 5 explains how selected Emerging Services and Analytics for business by virtual reality can be relevant and useful. Section 6 illustrates the Emerging Services and Analytics by virtual reality for healthcare research and show that outputs can be useful for research. Section 7 presents topics of discussion, and Sect. 8 ends this paper with conclusion and future work.

2 Overview of emerging services and analytics

This section presents an overview of Emerging Services and Analytics by virtual reality as follows. In Cloud Computing, Platform as a Service (PaaS) allows software developers to write, check, and correct their software and update any outputs. With the successful development, outputs can be executed in the form of libraries or user interfaces. With the substantial development, it is moving up the stack of Cloud Computing and Software as a Service (SaaS), to allow anyone without prior knowledge to use the service. There are different types of SaaS. Customer relationship management (CRM) is essential to the businesses that require strong collaboration with customers and ensure that customers with high satisfaction rate can continue supporting and purchasing products and services from their vendors [28].

2.1 Technologies involved with emerging services and analytics by virtual reality

A variety of technologies are required by Emerging Services and Analytics by virtual reality, although each service may use some of them with explanations as follows.

Database and data warehouse The collected datasets should be stored and archived in secure, easy-to-use, and reliable databases and data warehouse to ensure that the integrity and security of the data and datasets can be kept at the optimum [29]. Since not all the data and datasets can be used each time, intelligent systems are required in the data warehouse to choose the right data and datasets for each service.

Artificial intelligence and machine learning Artificial intelligence and machine learning can be used as methods for Big Data processing since Big Data services require intelligent algorithms, systems, and services to analyze and handle thousands of data sets, understand the relationship between all different variables, process all the requirements, and present all outputs [30]. All these complex processes can be completed in seconds to meet tough requirements and expectations from the stakeholders and users.

System and software architectures System and software architectures need to be defined, coded, and executed based on the standard such as agile development, MapReduce framework, and any software frameworks that can reduce the processing time and complexity [31]. The system and software architecture should support the development of libraries and application APIs to process data faster and provide an easy-to-use platform or software as a service.

Statistical computing and analysis Some data analyses still depend on statistical computing to interpret the meanings of regression and modeling outputs. Statistical analysis can perform regression tests and present key outputs [24, 32].

Visualization and graphical interfaces Visualization is important to present complex outputs so that the users will find them easy to learn and use. They can be directly computed as outputs, or they can be used from statistical analysis and transformed into visualization [23, 32]. The advantage is that the stakeholders can understand meanings of the outputs without asking specialists to explain in detail. This offers business the edge of competitiveness since less time is required to interpret complex business processes and data analysis. The businesses can understand the market trend and customer behaviors to make a better judgment. For example, a supermarket can understand the types of food customers buy each time and the range of prices; they can then suggest the same or similar

items with comparable prices, or even a list of what customers have purchased previously.

Predictive modeling and analysis This technique is based on all the above methods. Since data can be computed and analyzed, the challenge for the next step is to predict the types of items customers can purchase and the estimated range of costs involved, which are known as the predictive modeling of the customer spending [33]. This can create business opportunities for retailed businesses since customer behaviors can be predicted according to the previous records and then businesses can recommend them with better offers or special discounts for similar purchases.

Big Data services Emerging Services and Analytics by virtual reality include the characteristics and functionalities of Big Data, which include volume, velocity, variety, veracity, and value [34]. It means that all advanced data processing and visualization can be achieved with all these five Vs in place.

2.2 How do emerging services and analytics by virtual reality make a difference?

Although the concept is originated from Platform as a Service (PaaS) and SaaS, there is a difference between (1) PaaS and SaaS and (2) Emerging Services and Analytics by virtual reality as follows. PaaS and SaaS are focused on how services are operated and oriented. Emerging Services and Analytics are focused on the integration of different technologies on PaaS, SaaS, and core technologies described in Sect. 2.1. Additionally, services delivered by SaaS can allow users to understand the implications and consequences without the need to go for developers' training. Creating values based on the functionality, performance, and reliability of these services is important for Emerging Services and Analytics. Subsequently, Emerging Services and Analytics can be presented as a single and integrated service rather than different services that work together. There is only a service required which can blend different technologies together and perform seamlessly behind the scene to ensure users find outputs easy to comprehend. A challenge for current Emerging Services and Analytics is its domain-specific areas since requirements for each domain can be different. In order to demonstrate effectiveness and usefulness of Emerging Services and Analytics, specific examples in selected domains will be illustrated. The reasons why they have been chosen are as follows. First, there are issues for environmental, natural disaster, healthcare, social, and financial challenges. The knowledge to understand how they have happened, how to minimize the impacts, and how to prevent certain drawbacks can be beneficial not only to SaaS users but also to the general public if results of this scientific research are publicly available in the form of scientific research. Second, results, analysis, and interpretations can be useful for those who have followed up topics in these areas, so that they can acquire the knowledge and information they need to know. Examples will be illustrated between Sects. 3 and 6 to support the usefulness and contributions made by Emerging Services and Analytics.

3 Emerging Services and Analytics by virtual reality for climate change

Dealing with climate change is a complex issue since it requires the tighter control on the industry, people, and countries that produce high levels of carbon dioxide. First, it requires stricter regulation on industries, particularly those highly polluted industries, to reduce the amount of pollution and receive regular checkup on their pollution control. Second, it needs all the people particularly those developed countries to collaborate since it is involved in changing their habits and behaviors such as walking instead of driving for a short distance or reducing the use of air-conditioning systems. Third, countries that have produced high amount of carbon dioxide will require tighter control and fines on industries and people in their own countries. The use of Emerging Service and Analytics can simulate complex mathematical or computer modeling, organize all the data inputs and generate outputs efficiently, and present data outputs in the form of graphs, reports, interactive diagrams, and 2D or 3D visualization. These can ensure the outputs to be more readable, presentable, and connected to the scientists and anyone without much prior knowledge to understand and use. In this section, four main types of work will be demonstrated.

3.1 Sandstorm simulations

Sandstorm is considered a natural disaster although the extent and frequency can be accelerated through human activities such as industrialization, deforestation, and rapid urban development [35]. This is a serious problem faced in China, particularly in spring, late summer, and fall. The place that has been affected the most is Inner Mongolia since it is nearer to the dessert in Mongolia. Since China has undergone rapid industrialization and urbanization, the area of dry and deserted land went up in a fast rate. Thus, it brings the impacts of the sandstorm worse and more damaging each year. It is not only Inner Mongolia but residents in Beijing who have always suffered from air pollution, low visibility, and low air quality [36, 37]. This also creates health problems for residents such as lung-related diseases and puts their health at risk. In order to lower the impact of sandstorm to residents, scientists use different techniques to study. Zhang and Wang [38] use their numerical model to simulate sandstorm near the Beijing area and assert that sandstorm simulation can predict the date and impact of sandstorm to inform the general public. Liu et al. [39] use their

multiple-fluid model and 3D visualization on a graphics processing unit (GPU) to simulate sandstorm. However, all these methods are not easy to achieve and are expansive to build. This is an important topic since the air pollution in China has become worse over a period of years. Apart from human factors in which strict laws and close regulation are required to enforce, air pollution caused by natural disasters, particularly caused by deforestation and intense human activities that allow rapid development of waste land [35–37], should be investigated. Hence, this is the motivation to understand the impacts and consequences caused by sandstorm, particularly residents near Inner Mongolia and Greater Beijing areas since they have sandstorm problems several times a year.

The use of Cloud Computing and Big Data techniques can offer an advanced technical platform to simulate complex sandstorm and ensure that the extent of damage can be reported on time and presented in a way that the general public can understand. Figure 1 shows the sandstorm simulation that happened near the Beijing area due to severe weather conditions and rapid urbanization. The vertical axis shows the extent of the damage in the scale of 0.0 and 1.0. If it reaches 1, it means sandstorm reaches the maximum activity that the humans can tolerate in terms of health and it will have health concerns for the elderly and the weak and impact to the economic activities since the number of flights and transportation has to be reduced. The other two horizontal axes present the time of up to 15 weeks. Results in Fig. 1 show how the damaging impact of sandstorm can have health concerns in 15 weeks between years 2012 and 2015. Although there have been remedy actions such as planting more trees and preservation of natural resources between Inner Mongolia and the Beijing area, the extent of improvement has not been significant since the previous studies conducted in 2012 [40]. This is partly due to the volatile weathers that summer could go above 45 °C and spring could go above 25 °C in North China, and there is a mild shortage of rainfall in the last 3 years. Thus, the extent of damage caused by sandstorm has been greater than in the previous studies concluded in 2012. The use of Emerging Service and Analytics can provide an easy way to understand, and results can be presented to the general public about the awareness of their health and better living conditions.

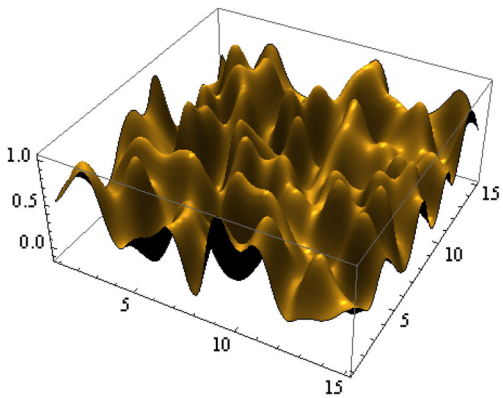

Fig. 1 Sandstorm simulations and impacts to health studies near and in the Beijing area

3.2 Clash of air pressures

The atmosphere has hot and cold air pressures, and each has its own influence to the weather. In summer, hot air pressure is stronger and can push away the cold air pressure, resulting in higher temperature. In winter, the opposite applies. During the change of weathers, particularly the spring and fall periods, the clash of air pressures is more common. Sea current can also bring air pressures from one continent to another. This can also create a period of unusual weather conditions. If warm current comes to the other side of the Atlantic Ocean, the temperature can go up between 5 and 7 °C than the average temperature and vice versa for the cold current. Hence, the study of the air pressure including how hot and cold air pressures clash and the impacts of their clash is significant to science [41]. In Asia-Pacific, severe clash between air pressures can result in typhoons, the combination of torrential rain and powerful wind causing destruction and flood. In Europe, it may cause 5 to 7 °C temperature outlier as described earlier. The use of Emerging Services and Analytics can simulate complex weather science, since it requires advanced mathematical modeling and regular computer modeling to check the results and rectify any discrepancies, since the outcome of air pressure clash can last for a short period of time or a few days or weeks. Figure 2 shows the outcome of a recent air pressure clash in 2015 near England. The color represents the temperature ranges of the air pressure. Red, orange, and yellow represent warm air, and green, blue, and indigo represent cold air. When both types of pressure clash, they may push one to another if one is more powerful. However, if both are equal in their strength, interesting observations happen in a way that

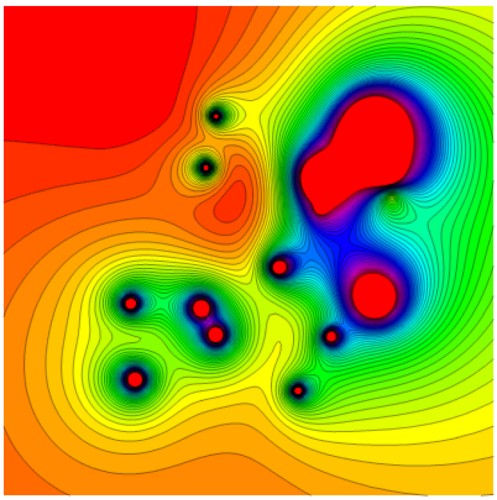

Fig. 2 The clash between hot and cold air pressure

each one begins to "engulf" the other. Results in Fig. 2 show such a case. The warm air tries to engulf the entire cold air, and the cold air splits itself into two halves to engulf parts of warm air which has been left behind. This can then explain why some English weather can be unstable for several periods between April and August. For example, 2 days can be rainy and cool in the temperature, then the next 2 days can be warm and sunny. In one case in July based on the simulated results, each day can experience a sudden change of weather, from cool/rainy day to warm/sunny, which then happens for a few days in a row towards the third and fourth weeks of July.

3.3 Temperature distributions of selected countries

Temperature distribution is an important way to show the forecasted or actual range of temperature experienced by each country on a daily basis, since reporters on weather news always broadcast temperatures of each major city of the country daily. This part of research is significant to weather science since the general public can check the temperature of the cities they are located in and know any forthcoming events such as rainfall after a period of sunny days. Intelligent systems and applications running on top of supercomputers have been adopted to simulate weather status including temperature distribution. However, the costs of running supercomputers are high due to the resources required to run the supercomputer center and recruitment of skilled scientists to perform 24 h of computational simulations. Hence, better models and methods that can run similar outcomes without the need to use and maintain a supercomputer will be very useful for ordinary scientists who do not have much funding. Pioneering work demonstrated by Chang [42] shows that hourly temperature distributions of the selected countries can be simulated through his latest Emerging Service and Analytics work in weather science applications. To ensure that work presented here is different from that paper, the example here is a weather distribution in New Zealand dated on July 31, 2015, at 11 a.m., as shown in Fig. 3. Different color codes correspond to the temperature range between sub-temperatures to above 17.1 °C. Results show that within New Zealand, the highest temperature was above 17.1 °C in the North Island and the lowest was below 0 °C at the far end of the South island. This means that within a matter of seconds, the general public can know the temperature and can wear and prepare the most appropriate attire for their day. Currently, this Emerging Service and Analytics can simulate weathers for the USA, UK, Germany, France, Italy, Spain, Portugal, Netherlands, Australia, New Zealand, Taiwan, China, and Singapore. The impacts can be enormous since it can affect the general public of the selected countries.

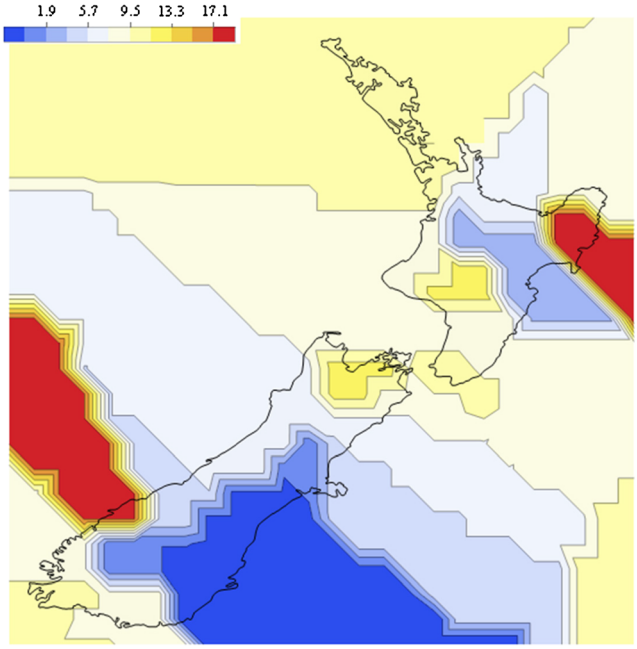

Fig. 3 Temperature distribution in New Zealand on July 31, 2015

4 Emerging Services and Analytics by virtual reality for analyzing natural disasters

There are natural disasters caused by the climate change and unpredictable earth activities such as earthquake. A large-scale analysis and predictive modeling always pose a challenge for scientists [43, 44]. This section presents the case of seismic simulations to model the detection and strength of the earthquake and also the tsunami simulations to investigate the full impacts caused by tsunami. Results are presented in visualization without the need for anyone to know complexity in data and numerical computing in place.

4.1 Seismic simulations

Earthquakes are not easily predicted since it is challenging to forecast the earthquake activities. Unusual animal behaviors have been studied to provide some warning to the humans, but it is not scientific enough without providing empirical evidence to back up. Identifying the moments that the earthquake will strike within 10 min, the moments that the earthquake strikes and measurement of the strength of the earthquake are significant to scientific research. Hence, virtual reality for seismic simulations can help achieve these objectives by identifying the critical moments that earthquake will happen. Knowing this information early can save more people's lives. Any technologies that can provide advanced warning before the occurrence of earthquakes can always be helpful, since people will have more time to escape and prepare for safety. Mobile apps can be used to provide warning to the people, but it has two issues. First, not everyone uses smartphones,

particularly in developing or third-world countries. Second, some services may be disrupted or subject to the recovery, since the infrastructure providing mobile services can be destroyed in the event of earthquake. Any technologies that can provide reliable, fast, and cost-effective services should be considered. Seismic simulations are used to understand the strength of earthquake and then predict where and how earthquake can happen and its extent in terms of destruction.

Figure 4a shows the seismic simulations showing the strength of the earthquakes. The intensity of the color shows the strengths of the earthquake. The darker the color, the stronger the earthquake measured. The one on the left shows dark red, which means it is a light earthquake that only chairs and tables can be trembling. The one on the right is the simulation of the earthquake in Nepal. Dark red in color means earthquake is at its full strength above the 8.0 Richter scale. In other words, the majority of buildings can collapse with massive trembles on the ground. Landslides and falling rubbles due to the collapse of building can kill thousands of people within seconds. Hence, understanding the strength of earthquakes and providing early warning can make a difference, since residents can have more seconds to escape from the possibility of building collapse. The use of Emerging Service and Analytics can be helpful since all the simulations can be computed in seconds and provide results in visualization to allow everyone to understand with ease.

4.2 Tsunami simulations

Tsunami happens due to the release of extraordinary earthquake powers, which have been liberated in the sea resulting in giant waves with extremely massive forces. It can engulf part of or the entire city within minutes depending on the strength of tsunami. Destructions have claimed thousands of lives and total destructions. The most well-known example is the South Indian Tsunami in 2004 and the tsunami hitting Japan in 2011 as a result of earthquake in the seabed. According to Lay et al. [45], the initial energy released by eruption in South Indian Tsunami was equivalent to 25 Hiroshima bombs. The use of Emerging Services and Analytics can help understand the extent of disruption, since they can simplify ways to comprehensively understand the complexity that causes tsunami and the extent of destructions presented by visualization. Figure 5a shows the occurrence of tsunami as a result of earthquake at the sea. Figure 5a shows the occurrence of tsunami in Japan in 2011 as a result of earthquake at the sea. Tsunami can build up forces and go forward. Purple indicated it was building power. Tsunami can move forward at the speed of 100 miles an hour to engulf everything in sight. All the powers are liberated within a matter of seconds and thus are extremely destructive. If the "destination" is not the land, Emerging Service and Analytics can simulate the area of destruction and the full impact.

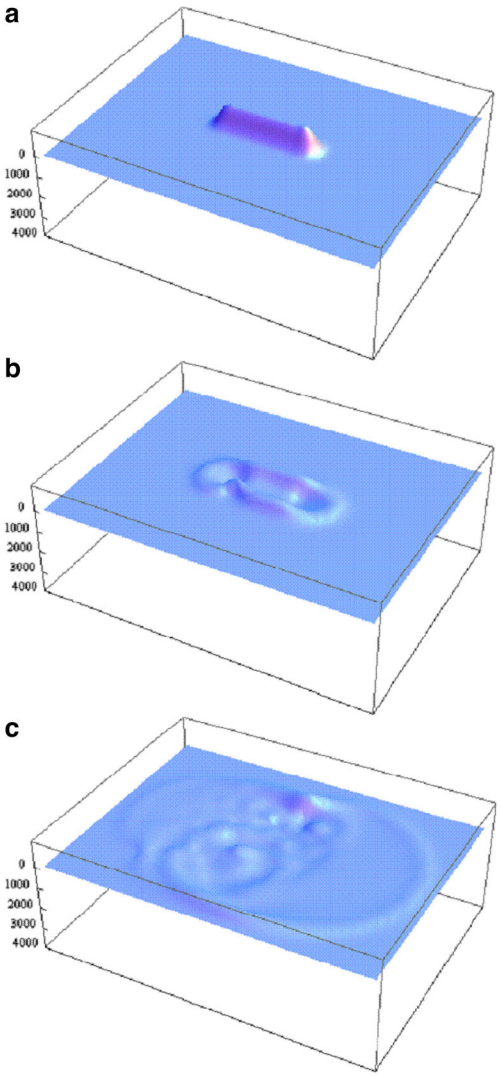

Fig. 5 **a** The occurrence of tsunami in the sea. **b** Investigating the full impact of the tsunami at the initial stage. **c** Investigating the full impact of the tsunami before the end of the tsunami

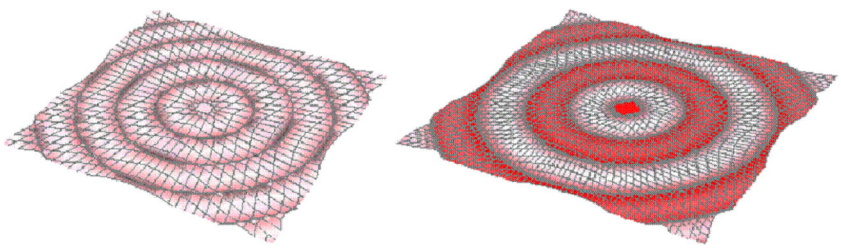

Fig. 4 Seismic simulations showing the strength of the earthquakes

Figure 5b then shows the full impact at the initial stage. Tsunami dispersed but transformed into waves with a huge power that could destroy anything in front. Dispersion can be continued further and spread cross. This is the point where it could destroy anything within 10 km of its affected area. In other words, if swept across inland, tsunami could destroy the entire city and neighboring towns within minutes. Figure 5b then shows the full impact at the last stage of the tsunami, which can be heavily felt and release thousands of tons of power per second that causes severe flood, total destruction, and loss of thousands of lives.

5 Emerging services and analytics for financial market, business modeling, and customer relationship management

In this section, examples are demonstrated for financial market, business modeling, and customer relationship management. Emerging Service and Analytics can provide useful outputs and analysis for businesses to provide added value, which includes better and faster services, cost reduction, improvement in business opportunities, and customer satisfaction identical to the objective of Cloud Computing adoption [22–24, 44, 46]. Each case is presented as follows.

5.1 Business intelligence as a service

Business Intelligence as a Service (BIaaS) is used to compute the prices and risks in real time to the selected stocks and also the prediction of the forecasted values, for example, the financial market analysis to study the prices and associated risks in the stock market. Emerging Service and Analytics can be completed with very low costs involved. One of the growing areas is to check and observe financial markets on smartphones, so that users and investors can check prices and risk in real time. In the example Business Intelligence as a Service (BIaaS) demonstrated by Chang [40], financial market analysis and prediction can be computed in seconds with the prices and risks tracked and monitored in real time. The cost of running the service is only on the electricity and computation time, which is negligible when results can be simulated in seconds. There is an example for BIaaS that analyzes stock options. Comparison with other works is as follows. First, Jeon et al. [47] present their pattern approach for prediction. They use Big Data processing and analytics to identify different types of investment pattern and calculate these patterns. Based on the forecasted pattern movement, predictive modeling can be achieved. Second, Sharma et al. [48] have developed their Black-Scholes-Merton (BSM) model for Cloud Computing economic models. They can calculate resource prices against investment time, contract time, rate of depreciation, and quality of service (QoS). However, the work is based on several assumptions without using any real data for analysis. The work presented by this BIaaS case study is to allow all prices and risks that can be calculated in seconds in real time and provide decision-makers important information before deciding to buy or sell more stocks of their choices. Figure 6 shows Google stock value between January 2015 and August 2015. The price per stock has risen from around US $520 to US $650 between July 2015 and August 2015. The bottom section of Fig. 6 shows the trading volume and the overall trend of the movement. This can make analysis easier since anyone without finance and economics degree can understand the performance of their invested stock with ease and all the data and outputs can be computed in seconds.

5.2 Social networks for customer relationship management and supply chain management

Social network represents the relationship between different individuals to understand the strength of the friendship and the associated impacts, which can be applied to the businesses [33, 49]. For example, if supplier A has better work relationship and better offers than supplier B in similar products and services, then the purchasing organization is more likely to use supplier A for their product services than supplier B. Similarly, if customer A has stronger ties, trust, and relation with business service provider C than business service provider D, customer A is more likely to purchase from business service provider C. Each circle in the social network presents each individual (or each company). Each link to all the circles is the status of the work relationship. The strength of the relationship is dependent on the number of links between each circle. If there are multiple links to one particular circle, it means there are more interactions with this individual for work. The same principal can be applied to businesses. Each link may mean a successful partnership, such as collaboration for an event, business venture, and project. The number of the links can reflect the strength and status with a particular supplier. Social network can be used not only in a social networking website but also in customer relationship management (CRM) and supply chain management (SCM) to study the relationship between people and businesses, businesses, and businesses similar to B2B, B2C, and C2C business models in electronic commerce.

Figure 7 shows the social network analysis for customer relationship management (CRM) and supply chain management (SCM). The one in the middle is the user for social network as a service to analyze his relationship with other customers and suppliers. Circles close to the center indicate these individuals have a closer work relationship with the user since there are multiple links connecting to them, establishing a “magnetic-like” effect. Those who have fewer interactions become the circles more distant to the center. The relationship management can be updated due to the change of

Fig. 6 Business intelligence as a service showing Google stock index between January and August 2015

circumstances. For example, if there are more collaboration and special offers, the distant circles connect to them with more links and may become the part of the closer circle after a period of time. The extent of the relationship between each work partner and customer can be presented by visualization and numeric number. The higher the number, the stronger the work relationship with more links in place.

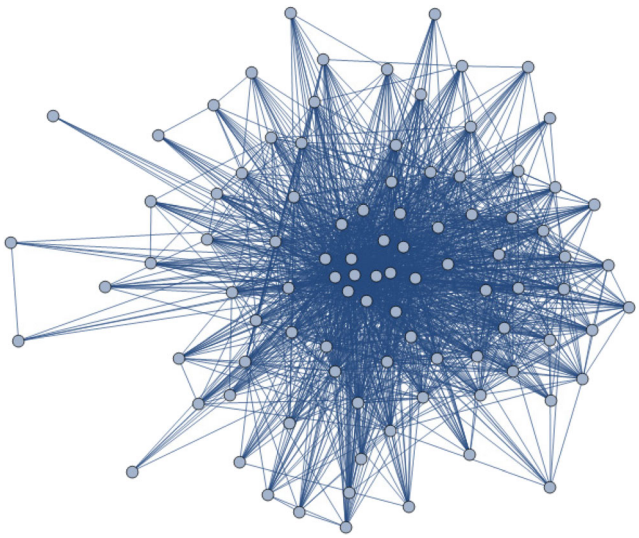

Fig. 7 Social network analysis for CRM and SCM

6 Emerging Services and Analytics by virtual reality for healthcare services

Healthcare services always pose challenges since different types of bacteria, viruses, and diseases can be developed from time to time. The case of cancer studies has been available for a significant period of time, yet scientists still try to develop methods that can improve the current medical treatments. The use of chemotherapy and radiotherapy can kill a large percentage of cancerous and healthy cells and thus may create negative impacts to the patients' health regardless of the fact that cancer treatments are successful. The use of the modern techniques will only target at tumors that are malicious to human immunity. In order to understand a large quantity of data, experiments, and operations involved, Emerging Services and Analytics have played an important role for healthcare services since it helps scientists understand the complexity of the problems they face and the correlation between different datasets [50]. Surgeons can look at the tumors in the patients without performing surgeries first. Similarly, surgeons can diagnose the health conditions of diabetes patients prior to any medical treatments. This section introduces a current state of the art contributed by Emerging Services and Analytics.

6.1 Brain segmentation

Brain science poses a challenge since it involves understanding how humans think and react ranging from simple to complex activities. This requires advanced methods to analyze how the human brain works and the response from the brain cells with regard to those activities. Miranda et al. [51] have demonstrated brain segmentation by Cloud Computing and have presented results. These brain scanning and segmentation are very expensive and are not cost-effective for scientific research if multiple and repeated times of undertaking brain segmentation experiment is necessary. Thus, any pioneering way that can achieve brain segmentation with cost-effectiveness can be investigated. For example, Chang [52] investigated the brain segmentation to two groups of volunteers performing dancing and evaluated their brain activities when they were involved in dancing. The aim is to understand which part of the brain segment is responsive and the extent of responsiveness with regard to dancing. The study involved the use of modern Cloud Computing technologies to collect data, analyze data, and visualize data within seconds to allow scientists to understand the extent of the brain cell activities. The study shows that the lower part of the brain segment is the most reactive to dancing since they are in charge of body movement, balance, heartbeat rate, and blood pressure directly. The region in control of emotion has been on high activities since dancing can make the volunteers feel happy, physically involved, and relaxed at the same time. The use of Emerging Services and Analytics can reduce the level of complexity to allow scientists and students to understand the impact to the brain segmentation in dance. This form of service is efficient and economical since all results can be computed in seconds without the need of spending millions of public money. Figure 8 shows the brain segmentation image when volunteers were involved with different types of dancing. The activities of the brain can be represented by the intensity of different brain segments. The darker the colors, the higher the intensity level.

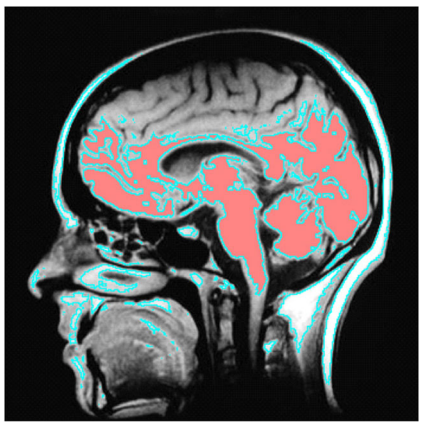

Fig. 8 Brain segmentation in action

6.2 Insulin molecules and type I diabetes

Type 1 diabetes can be controlled by the injection of insulin to reduce the level of glucose in the body. An interesting research direction is to study the insulin molecule so that the rate of regulating the level of glucose can be improved. In other words, an insulin molecule can act more proactively like our body enzyme to increase the rate of glucose utilization. The pioneering research with the use of Emerging Services and Analytics helps transform all these complicated concepts into a simple way that allow the audience to understand. The services can visualize the structure of an insulin molecule before, during, and after controlling the amount of glucose in the human body. As shown in Fig. 8, different color codes mean different levels of reactions on glucose. Red means the area in the process of "digesting" glucose. Yellow means the active region responsible for such natural reactions. Blue means at the completion of glucose "digestion." The end results can show science students who can interpret the complexity with ease since every detail in the structure can be presented visually. Each part of the insulin molecule can be magnified to ensure that students and scientists can check fine details, shown in Fig. 9 [40].

7 Discussion

This section presents four topics of discussions. First, it is the Emerging Services and Analytics by virtual reality for security, since security and privacy play important roles in the digital world that all types of applications and services should stay safe and protected. Second, the summary about the environmental and natural science has been presented. Third, the topic has the summary of contributions offered by Emerging

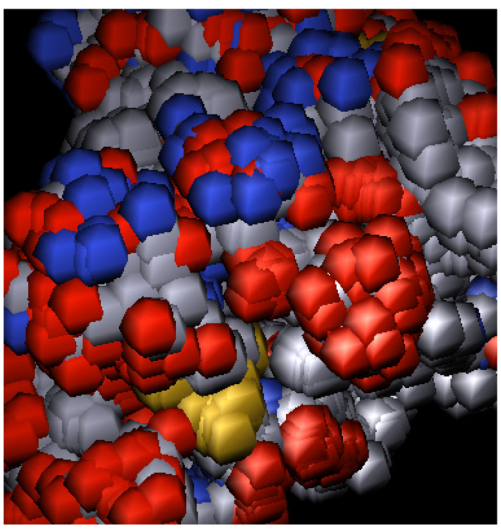

Fig. 9 The detailed structure of an insulin molecule

Services and Analytics. Fourth, discussion includes the future direction of Emerging Services and Analytics.

7.1 Security

Security plays an important role in all types of digital services, and it ensures the safety and protection for all users, data, and services involved. Users need to feel safe in using a service and improve their trust in the use of digital services, including Emerging Services and Analytics [53]. Privacy is important since users do not wish their personal information leaked or compromised. For example, intrusion to privacy can create problems such as the dissemination of sensitive data or private photographs received on the wrong hands. For example, the hacking of celebrities' accounts on iCloud resulted in private photographs circulated around the internet [54]. Patients' data can be lost due to the careless handling of personal information [55]. In order to deal with hacking and unauthorized access, Emerging Services and Analytics are useful since it can analyze thousands of data in seconds, understand the complexity, and present them in a way that system managers and organizations can be alerted instantly about any abnormal activities [50, 56]. There are also different types of Emerging Services and Analytics for security. For example, Avast antivirus has introduced the security services which allow the users to check activates in their personal computer and present information such as the number of scans per month, the number of viruses blocked and detected per day or month, and the alerts raised per day or per month. Users can be informed immediately when malicious files or viruses are blocked whole visiting infectious websites. However, many security solutions are based on one type of solution and the integrated approach will prevent more attacks and offer better protection [57, 58]. In the example demonstrated by Chang and Ramachandran [59], a multi-layered security based on the integration of firewall, identity management, and encryption has been implemented to ensure that all data and services in the Cloud can be safe and protected. In order to demonstrate the robustness of the integrated security, a large-scale penetration testing was conducted and performance between a single-layered solution versus a multi-layered solution was compared. Their result demonstrates that the multi-layered security solution can block 99.4% viruses and trojans versus around 70% offered by a single-layered solution. Thus, the integrated security for Emerging Services and Analytics can be useful to reduce the extent of malicious attacks.

7.2 Environment and natural science

Sections 3 and 4 present different cases for environment and natural science. Each case is independent and unique. They are not the same since the mathematical models are different, requirements are different, input variables are different, and each country of the study is different. Referring to Sects. 3 and 4, sandstorm simulation is a case study near Inner Mongolia and the Beijing area in China. The clash between hot and cold air pressures has been studied in England to investigate the rapid rise and fall of temperatures within days. Temperature distribution in New Zealand has been investigated and presented as visualization analytics. Seismic simulations are generic but can be adapted to analyze the impacts of the earthquake in Nepal. Tsunami simulations have been used to study the impact of tsunami in Japan in 2011. All these simulations and examples show that other than natural disasters like earthquake and tsunami which cannot be prevented, the environments have been affected by human activities that result in more extreme weathers such as sandstorm, unstable air flows, and unstable temperature distributions. Emerging Services and Analytics in Cloud Computing can help scientists study the impacts of environmental challenges such as global warming and effects of pollution.

7.3 Contributions by Emerging Services and Analytics by virtual reality

Contributions are as follows. First, Emerging Services and Analytics by virtual reality can process a large amount of data and datasets by intelligent algorithms and simplify the process to understand the complexity of outputs since results have been presented in a way those users can relate and understand with the minimum amount of effort as demonstrated in the paper. Second, Emerging Services and Analytics by virtual reality have been successfully blended with scientific research and activities from health care, business with finance, climate change, natural disaster studies, and security. All the work in different domains can be successfully demonstrated.

Selected outputs with their explanations can support research contributions made in each domain of scientific studies. Third, the efforts demonstrated by Emerging Services and Analytics by virtual reality can bring closer between different disciplines, since the software algorithms developed by one domain can be reused and reimproved for dealing with similar problems. For example, if there is a request to process and analyze thousands of datasets within seconds for health care and finance, the only change required is the type of datasets and what type of data formats to handle, since the core algorithms do not differ very much. This paper presents next-generation virtual reality technology and explains their positive impacts after delivering these services to users of different domains.

7.4 Limitation of this research

The current focus is to demonstrate the effectiveness of Emerging Services and Analytics, which serve as a virtual reality enabled by Cloud Computing. All selected examples

have been discussed in details. There are limitations as follows. First, all the new services will require a period of time for development and understanding the real benefits and impacts to the user groups. In the worst case, it may mean after spending some time, it is not meeting users' real requirements. Second, more technologies and services can be undertaken together to make Emerging Services and Analytics better. One of such areas is the Big Data processing by intelligent algorithms and deep learning. The impacts can accelerate the analysis of results and improve its accuracy. The new development will thoroughly improve the quality and delivery of Emerging Services and Analytics based on these two directions.

7.5 Future directions of emerging services and analytics by virtual reality

Big Data analytics and Big Data processing provide business agility and improvement in efficiency at the same time, since the requests of all kinds that contain lots of data or datasets can be processed, analyzed, and interpreted in a short period of time. As a result, organizations that adopt such services can have a higher level of competitiveness. For example, business analysts can spend much less time and effort in understanding complex datasets. They can focus more time and effort on improving the quality of the existing services, creating new business opportunities, and improving work relationship with their stakeholders, investors, customers, and collaborators. Businesses can have more options to exercise their strategies since they can understand their business performance of different units and projects with simple clicks. The advantages offered to businesses can make them steps ahead of their competitors. In sectors such as smartphones, new changes, new developments, and new trends can be analyzed within a short period of time to offer the smartphone companies additional edge over their competitors. The future directions mean that business analysts can use more Emerging Services and Analytics for their daily jobs to analyze different types of data and performance of different projects and units. All the progresses in new projects and services can be monitored and updated in real time. The businesses can stay more agile and fast-paced to meet different demands in the market and customers. Directors can have all the up-to-date information in their smartphones and discuss with their stakeholders, investors, and employees face to face via teleconferencing and facetime-type services. Government officials can check these services and identify whether the impacts are caused by climate change, natural disaster, business intelligence, health care, and social problems. They can make immediate actions to minimize impacts to the minimum. Before natural disasters happen, they can do enough preventive measures to save more lives and less destructive impacts. In summary, all the success factors, key performance indicators, and performance metrics can be analyzed in real time to ensure businesses can check their profits, progresses, spending, problem updates, and topics of discussion at any time.

With regard to the scientific communities, there will be more contributions and impacts offered by Emerging Services and Analytics by virtual reality as follows. First, scientists can spend less time understanding the datasets and working out correlations between different variables, since the process of data analysis can take up a significant amount of their time. They need not perform more statistical analysis to work out multiple correlations since all the results and all the relationship between all variables and all the datasets can be all processed and presented. Second, Emerging Services and Analytics by virtual reality offer them easy-to-use services, so that they may spend seconds understanding the complex scientific theories and principles rather than days figuring them out. Simulations produced by Emerging Services and Analytics can allow them to study on the areas they would like to investigate further. For example, if they can see tumors in the brain, they can use Emerging Services and Analytics by virtual reality to enlarge and scan to allow them to identify the exact spot and the size of the tumor, so that it can help with the precision in the surgery. Scientists can also repeat the simulations as many times as they like so that they can explain to other colleagues or stakeholders who do not have the background knowledge. It can improve the way people communicate since these simulations can explain the complex human bodies such as cells, proteins, tumors, and immunity work. Third, the boundary between different disciplines is getting thinner since scientists at different domains can experience similar problems such as processing thousands of datasets to achieve a good performance, or Big Data Analytics that can show all the complexities involved in different types of science. This can enhance the inter-disciplinary research encouraged by the current academic practices and funding requirements.

8 Conclusion and future work

This paper presents a high-level overview of Emerging Services and Analytics by virtual reality and introduces a number of selected examples in different domains. The technologies behind, the rationale, and the advantage of adopting Emerging Services and Analytics by virtual reality have been explained. The use of Emerging Services and Analytics by virtual reality can be extremely useful to businesses and academia as follows. Businesses can achieve business agility, improvement in efficiency, monitoring the daily work, and analyzing key performance indicators up to date and in real time. Scientific communities can acquire greater contributions and impacts since scientists can spend more effort and time on their core research rather than understanding correlations

between different databases and processing large-scale data. Examples in health care, business, climate change, and natural disaster have been demonstrated to support that Emerging Services and Analytics by virtual reality can allow scientists and the general public without much background to understand the complexity behind science. Not only scientists with deep knowledge but also the general public can understand part of the outputs and illustrations from weather science, sandstorm simulation, air pressure clash, seismic simulations, tsunami simulations, business intelligence, social networks, brain segmentations, insulin investigation, and other examples. Security and future directions have been explained to support contributions offered by Emerging Services and Analytics virtual reality. Future work will include the integration with existing services and with other technologies from Big Data, Internet of Things, and Cloud Computing to jointly present a joint Emerging Service and Analytics virtual reality to process requests from different domains.

Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

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