Visualization of Uncertainties and Noise in Dark Data: Methods & Techniques

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Abstract: Big Data generated in today's digital world is overwhelming the capacity of institutions and researchers managing and making use of it, leading into a new crisis called the data deluge. Forbes estimates 2.5 quintillion bytes of data created every day, 90% of it being unexplored and unanalyzed complex Dark Data. As much as 80% of business organisations rely on costly manual processes for locating, organizing and processing a small fraction of such untapped data. The lack of automation tools to improve the productivity and Dark Data utilization motivates to explore domain and define problems. This work aims to minimize expensive storage and security issues and reduces dark data volume which is still unanalyzed and disvalued. The methodology proposed to improve spatial-temporal efficiency by injecting intelligent insights into diverse and continuously evolving data silos by uncovering and transforming the value of unanalyzed Dark Data through application of Cognitive Visualytics and Intelligent Process Automation (IPA) techniques. Moreover, the work intends to apply cognitive visualization techniques to finding the solution of the uncertainty faced in dark data leading to the conclusion of the work by offering not only dynamic, interpretable and multidimensional Dark Data visualizations, but will also allow diverse data providers make an informed decision by predicting Dark Data analysis.

Keywords: IPA, Dark Data, Data Visualization, Analysis

1.Introduction

The digital universe consisting of all the data that we create and spread annually is doubling in size in approximately 12 months. Total Data size in the year 2020 has nearly reached to 44 zettabyte which is equal to 44 trillion gigabytes [6]. The total digital bits in 44 zettabytes are nearly equal to the stars in the universe. At the end of 2030, out of this total data nearly half of the data will fall in the category of unstructured data. A sudden violent bursting of data is of course far outstripping capacities to use it [21].Today, artificial intelligence and data analytics covers most of the job opportunities, it is advised to pour concept of visualization into it [9]; so that the programming and non-programming based extended reality tools will create help for immersive generation of the output. A birth of dark data can be through the following reasons:-

A traditional small fractional data is mostly available in structured and accessible form, which is use by the organization with the low investment for maintaining and securing of the data, whereas

A non-traditional or larger data also called as larger section of the bid data is unstructured but at least somewhat accessible. Some part of this unstructured big data is mostly unseen and unused; this may be also called as the not required hidden data. This can be called as dark data [19].

A concrete link of dark data may have compositions like:-

- Unused Data
- Data Behind the firewall
- Hidden Data
- Restricted Data
- Not Accessible Data
- Slow Data
- Unstructured Data
- Unconnected Data
- Redundant Data
- Idle Data

When developing and during the actual implementation of data analysis, scientists, Industries, corporate sectors and engineers consider several critical factors such as:

- Software Features and Functionality
- Performance Measures of the software;
- Ease of setup as far as hardware & Software is considered;

- Maintenance & other customized Need/Issues

Considering above metrics, the data visualization features which now a days is considered as most effective approach for analyzing the results of data analytics can be added with the software or the module. It will help the analyzers to easily identify the results and make appropriate decisions [18]. The module no doubt will have required data analytics algorithm with a general or generic visualization tools with extended reality features, which can also be termed as Visualytics or Visual Analytics.

Data visualization techniques have integrated useful functions such as data pre-processing, visual analysis into a library [21]. As a result it enables users to simplify the procedure required for the data visualization by using both a programming language and tools with non- programming languages to invoke the function or using the pre-integrated function directly. Visualization tools also facilitate user's to transform every element of the data into interactive charts [21].

2.SignificanceOf The Study

The need to reduce or remove unwanted data is now the main objectives of big organisation. Companies are spending half of its project cost on security concerns of data. Looking at the ratio of Data Size, everyone should be aware while collecting and gathering data. Many organizations pay in billions to acquire data, data in the organisation is mostly needed to multiply the business. Currently India and major developing countries is having business startups explosion, Under Atmanirbhar India, near about 2000 startups have already been initiated. Looking at this, it is most important to make aware every involved individual about the need of data with its analysis techniques, identifying unused data with its hazards [11]. One should also know the difference between usable data and unusable data, importance of quantity and quality of data with maintenance cost of the same. Analyzing dark data and converting it into structured data to retrieve useful data is surely the need of an individual.

As we agree upon ―slow kills companies fast‖, there is a need to apply intelligent approach for consistent growth. Business Intelligence can be best implemented with charts and pictures; the analysis performed on the generated charts and graphs is more effective than the raw data. Data visualization will help the core committee of the organisation to take appropriate decision and that too very frequently. Scientific visualization, information visualization, and visual analysis make it easier for the organisation to extend their business [13].

3.ReviewOf Related Studies

The data is the most important asset for any organization, 70 percent of the growth and decision making strategy of the companies depends on the analysis carried out on the data. According to **Njeru Mwiti Kevin** et al; insight data leads should be understand well with cost cutting techniques which will help in avenues to the organization.The unstructured data affects the processing performance and increases the difficulty of the user. The methods were presented by **Wael M.S. Yafooz** et al; are often used to manage unstructured data in relational databases using query structure. Relational data contain a huge amount of untouched data, and if these data are not organized properly, they will be meaningless and not useful. The important challenge faced is to extract the knowledge from the unstructured data. Researcher have used internal database schema to handled unstructured data. **Shunan Guo** et al; discuss and resulted that in Event sequence prediction most of the data analysts apply statistical method and machine learning techniques while travelling through the result phase. In event sequence prediction the most difficult part is to convey uncertainty and finding alternative paths or possible outcomes. Researchers in their study conducted a study with 18 participants where they have included 05 machine learning practitioners; in this study, clients have confidently decided to go with alternative predictions, also they have preferably and mostly measured and followed alternatives deciding between the two options which were available [19].

In 2010, **Gregory S. Nelson** predicted that in a few years, data would come at organizations in every form imaginable. Video, text, email, conversations, photos will dominate our databases in the future. Systems that force us to structure information in rows and columns will be out-dated. Looking at the trend to date, this is already happening. **Gartner**, with Analytic platforms Identifies two BI and analytics capabilities: their first argument is that, it enables for business user data mashup and modelling; internal platform integration; metadata management; cloud deployment; development and integration and BI platform administration. Data mashup refers to the integration of data from multiple disparate sources to provide users with at-a-glance view of their business performance. This user-driven combination of data from different sources enables the creation of analytic models such as user-defined measures, sets, groups and hierarchies. The "advanced capabilities include semantic auto discovery, intelligent joins, intelligent profiling, hierarchy generation, data lineage and data blending on varied data sources, including multi-structured data". Of importance is the capability of data mashup in illuminating dark data is the fact that most businesses today have too much data stored in several disparate systems; therefore, unless businesses are able to integrate this data into a single source, then it becomes increasingly difficult to

process data that cross different system boundaries which could otherwise have been possible if the data was integrated. Once this data is integrated, analytical tools can then be applied to enable the statistical evaluation of this rich integrated data source and the identification of patterns within the data

4.Objectives Of The Study

- To study and correlate the uncertainties and the noise within dark data with four V's of big data i.e. Volume, Velocity, Variety and Veracity.
- To analyze the model for feature extraction and classification for dark-to-smart data conversion.
- To discussa method for applying cognitive visualization techniques to evaluate the effectiveness and uncertainty across large volumes of Dark Data.
- To compare Data Filtration algorithms for identifying Dark Data.

5.Dark Data

Dark data is defined by Gartner[13] as "As the information assets organizations collect, process and store during regular business activities, but generally fail to use for other purposes (for example, analytics, business relationships and direct monetizing)." This definition is even made simpler by [14]who describe it as data that business and industry are paying to store, protect and manage yet it isn't being efficiently utilized to improve the value of their business. According to research by the Compliance, Governance and Oversight Counsel, 69% ofa company's stored data has absolutely no value to the organization. So, why keep it? They thus propose the use of content-based retention policies that will empower you to keep only data that is important to the business hence gaining more benefits.

According to [14], keeping only content with business value can reduce retention costs by up to 70 percent. [14]Identifies five approaches that can be used to unveil dark data: Managing the growth of storage: this ensures that the organization keeps only data that has value to the business; Holistic capture of data: which ensures that all data produced within the organization is collected and storedDeliver self-service access; because each group of users in your organization require different type(s) of data to support their duties, giving the users self-service to search for the data they need themselves from the organization's archives because they are the ones who know what they need most. This maximizes workforce productivity with transformational business insights into the stored data. Automation of the data lifecycle: establishing set governance policies for defensible content deletion can be a significant key in the reduction of "dark data." Defining a clear lifecycle for the data from the time it is created to when it is deleted. This helps not only to automate records retention but to also manage your data more strategically for improved compliance and litigation readiness. Assuring compliance and discovery: this helps to reduce costs and risks with enterprise-wide search and the efficient discovery of all Electronically Stored Information (ESI). It also ensures that the discovered information is simple and defensible and makes it easier for legal and compliance requirements.

[3] identifies four stages of lighting up data in an organization: Identification; Classification of data; Controls and Continuous monitoring. The Identification phase tries to find out what data the organization has and where it is stored (either within or outside the organization); classification organizes the data into groups to reflect the structural organizational needs or processes within the organization; the control stage manages the data that has been organized to ensure its security and integrity. This stage also introduces data analysis which ensures that the organization is able to gain insights into the data for business intelligence. Continuous monitoring ensures that proper mechanisms are put in place to ensure that the data is continually maintained to serve the needs of the organization. This stage also ensures return on investments (ROI) and identifies areas of improvements. This captures the overall concept of illuminating dark data using analytics (manage) because much of the data within organization is usually unstructured and can only be made usable if we are able to mine it and extract useful patterns and relationships which would the firm into making the best business decisions.

According to [2], companies will continue to waste 80% of customer data they have collected. Even more, the international data corporation (IDC) estimated that in 2013, only 22% of all the data in the world was useful (could be analyzed), and even in that case, only 5% was actually analyzed. A University of Texas study put these general estimates in a business context: it found out that for the medium Fortune 1000 company, a mere 10% increase in the usability of its data translates to an increase of $2.01 billion in annual revenues and a 10% increase in remote accessibility to data translates into an additional $65.67 million in net income per year [2].It should be noted that data that cannot be analyzed is useless to an organization.

The idea of the business process was proposed by [10]; they propose that BA process is premised on answering the question: What valuable or problem-solving information is locked up in the sources of data that an organization has available? Additional questions need to be answered at each of the three steps that make up the BA process. Answering all these questions requires mining the information out of the data via the three steps of analysis that make up the business analytics process.Descriptive statistics is the first stem and it is essential because generally, the size of some data sources can be unimaginable, complex and confusing thus this first stage helps in sorting out the data and making some sense out of its informational value. This may include sorting out

the data, cross tabulations and applying the measures of central tendency onto it to restrict the data into some more manageable size. Other measures such as plots, charts and graphs can be applied in order to help decision makers visualize the data in order to understand content opportunities. From this stage, some patterns or business behavior can be identified representing targets of business opportunities and possible future trend behavior. All this can be carried out using an application such as Microsoft excel. This is explained in Figure below

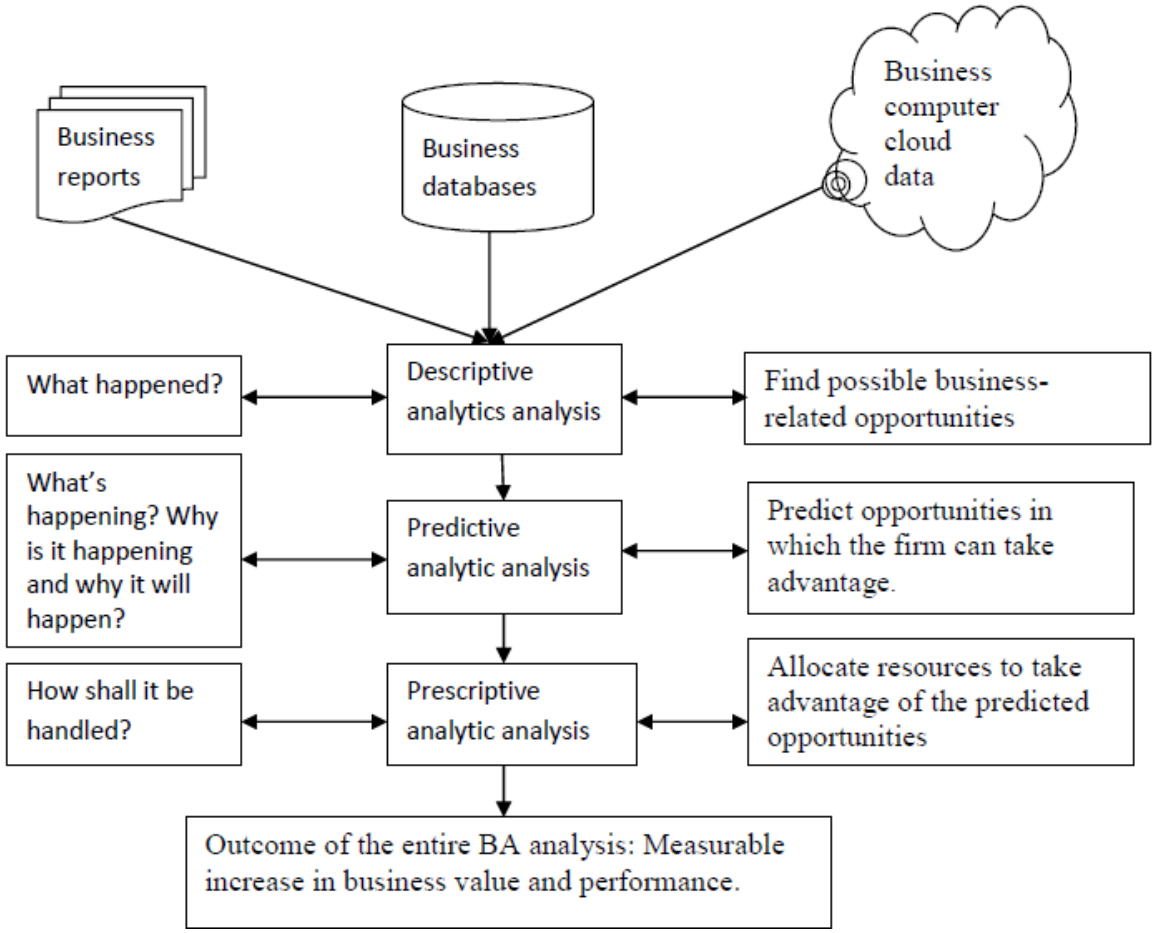

Figure 1: Business Analytics Process[21]

6.Key Mathematical Concepts In Big Data Analytics

Mathematical sciences have been contributing to analyze big data but there is still plenty of room for the development and the contribution to be made in this domain. Among many directions of the works that could be made in the directions mentioned, the contributions can be made by providing various mathematical tools that are innovatively designed; to analyse and manage huge complex data, to design and develop inference systems to conclude on noisy and large data, and to develop mathematical algorithms from the major sub-fields of mathematics such as linear algebra, and to perform computations for large sizes of data through various mathematical representations or data structures for data.

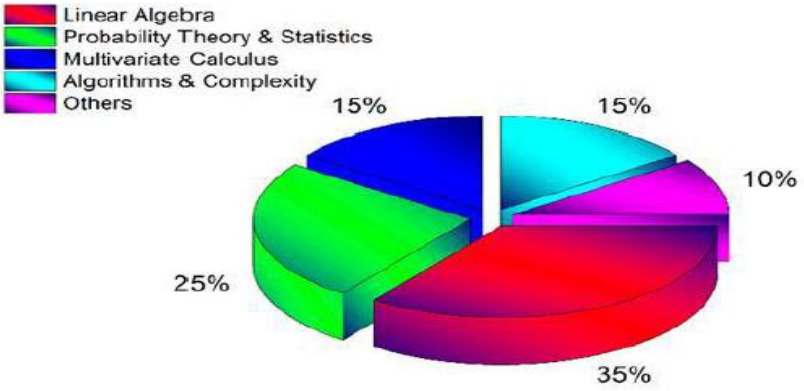

Figure 2: Graphical representation of Mathematical approaches for big data[23]

Figure represents the importance of mathematics in big data that is most recently found in the literature [20]. The topics in linear algebra such as matrix operations, vector spaces, Eigen values, Eigen vectors, orthogonalization and orthonormalization are required to understand as they map with the concepts of optimization techniques used in machine learning [20], the tool that is widely used in the field of knowledge discovery processes, such as data mining. The topics in probability and statistics like combinatorics, theoretical distributions, and sampling methods are required to understand as they are mapped with the concepts of feature selection and feature extraction used in the domain of big data or data mining. The topics like differential, integral calculus, vector calculus, data structures, dynamic programming, and randomized algorithm are required to understand as they are mapped with the key concepts related to the computational efficiency of any algorithm studied to discover its space and time complexity [21].

- **Eigen Values and Eigen Vectors For Big Data Ranking**

The figure shows the typical example of Eigen values and Eigen vectors. The work finds the Eigen values and Eigen vectors of a particular system that is perturbed using known values.

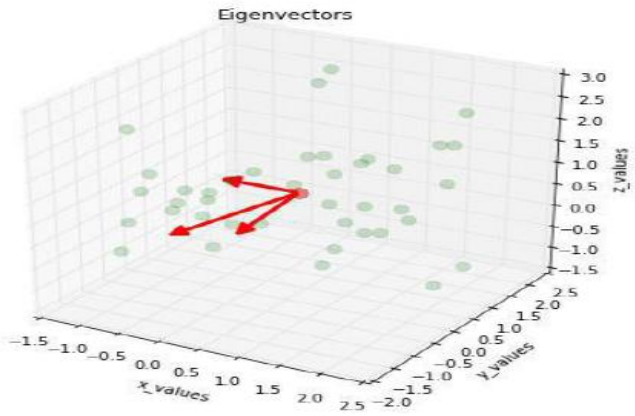

Figure 3: Eigen values and Eigen vectors [20]

- **Graph Laplacian And Big Data Clustering**

The Laplacian matrix is a matrix representation of graph describing properties of a graph. This has wide applications in machine learning. This matrix is as defined in the equation (1).

L=D-A

The computation of degree matrix is defined with the following property:

D[i][j]= degree of node i if i=j and 0 if i≠j

The computation of adjacency matrix is defined with the property:

A[i][j]= 1 if there is an edge between node i and node j, Otherwise 0

Mathematical modelling is developing models describing a system using mathematical concepts and language. These models can be dynamical, statistical, differential or game models. Algorithms based on these models yield better performance during dynamic data handling under various circumstances. Also mathematical models play vital role in data mining. Mathematical models of big data can help various sectors to meet their challenges and can also be extended to various other domains. The mathematical models used by researchers are inspired by exposure in mathematics [10]. Mixture of models has drawn attention of many researchers aiming at analysis of data clustering [12]. Many models result in effective revealing of structures of clustering [23]. Mathematical based models have importance in scientific simulations estimating and extrapolating the reduction ration helping scientists to take decisions on data compression. Mathematical models become key element in development of multigrid algorithms from graph Laplacian systems.

7.Dark Data Analysis Model

The data preparation, gathering and data observation and validation process will be followed by data analysis phase [10]. In data Analysis the analysis of the dark data in the big data will calculated. The dependencies of actual data with dark data will also be identified:-

- Descriptive analytics
  It basically uses data aggregation and the concept of data mining to show what has happen.
- Predictive analytics
  It is based on statistical model too understand the future. Prediction and forecasting techniques will be used.
- Prescriptive analytics
  Decision making based on the comparative results.

Automated rule-based workflows can be further enhanced with decision-making capabilities. As a result, forward-thinking organizations that have already adopted intelligent process automation technology are realizing greater efficiency levels, improved staff performance, less risk, better response times and ultimately more positive customer experiences [5]. Intelligent Process Automation (IPA) refers to the application of Artificial Intelligence and related new technologies, including Computer Vision, Cognitive automation and Machine Learning to Robotic Process Automation [2]. Additionally, it provides an end-to-end automation of Dark-to-Smart data diagnosis and decision-making based on the historical practices for continuous refinement of its value assessment encompassing the analytics requirements of diverse stakeholders [18]. The work and implementation will try to achieve this by researching IPA methodologies to automatically identify, classify and extract multilateral unstructured Dark Data and implement intelligent data-to-function-aware cognitive agents to effectively scan the data landscape of an organisation, label and annotate Dark Data, analyse the degree of darkness based on multi-dimensional explicit and implicit features and diagnose its cause to control volume growth through automated retention and defensible removal [1] [3] [5].

- Generic Visualization Tools

Data visualization is required for business intelligence, scientific visualization, information visualization, and visual analysis can be achieved with;-

Tools without the Programming Language - JS based

Tools Based On a Programming Language -Java, .net, embedded extended reality

As the basic work includes the visualization of the uncertainties, it is important to understand and compare different visualization techniques.

Table I: Comparison of visualization tools based on Java Script [16]

S. No	Framework Name	Input Data format	Features	Charts Rendered by
1	D3.js	JSON, CSV, and XML	It contains a powerful D3 gallery with option of multiple charts, graphs, and maps including the world map	HTML5 canvas, SVG and CSS
2	Chart.js	JavaScript API	Total 8 types of inbuilt chart types, including over 23, charts and graphs.	Only HTML5 Canvas
3	FusionCharts	JSON, XML	Charts and graphs of more than 90 types, 1000 plus maps including all continents, major countries.	SVG, VML
4	Flot Chart	JavaScript API	The charts of lines, points, filled areas, bars and any combinations of these charts. Doesn't support maps.	Only HTML5 Canvas

5	ZingChart	JavaScript API	Collection of chart and graph types in the gallery. Support almost every country and area.	HTML5 Canvas, SVG, and VML

Table II: Comparison of visualization tools with programming language [16].

S.No	Framework Name	Input Data Format	Language-based	Features
1	Gephi	CSV, Excel	Java, OpenGL	Powered by OpenGL engine. Force-based layout algorithms shape the graph.
2	Nodebox 3	CSV	Python and Clojure	Integrate all the functional parts in nodes.
3	Ggplot2	R, API	R	Plotting based on layers. Graphs composed of layers.
4	Processing	Library Formats	Java Python	Integrate the OpenGL engine. Over 100+ libraries offered to expand its usage.
5	JpGraph	CSV, MySQL	PHP	Tiny size of generating images. Anti-spam images are supported. 3D effects are also supported.

8.Conclusion

Visualization has played a significant role while making decision in most of the complicated situation. Dark Data filtering and Identification using visual variables quantify geospatial and temporal uncertainties across diverse data silos by leveraging extended reality & Computer Vision techniques coupled with predictive information mining to improve the visual classification of Dark Data. Extended reality makes the impossible possible and its potential is just beginning. Machine based learning including other factors may create uncertainties in the data which may affect the final results.

This works will lead to provide analyzing uncertainty and mapping its variables to visualization for providing more appropriate results to support decision making rule based identification of the unused data and injecting the same with intelligent process automation to remove uncertainty and noise from the visual variable will help the user to compare results with and without uncertainties. The proposed method will help to add intelligent automation for calculating results.

References (APA)

A. F. Md Ajis and S. Hajar Baharin, "Dark Data Management as frontier of Information Governance," 2019 IEEE 9th Symposium on Computer Applications & Industrial Electronics (ISCAIE), Malaysia, 2019, pp. 34-37. 11

A. N. Ramaseri Chandra, F. El Jamiy and H. Reza, "Augmented Reality for Big Data Visualization: A Review," 2019 International Conference on Computational Science and Computational Intelligence (CSCI), Las Vegas, NV, USA, 2019, pp. 1269-1274 15

N. A. M. ElSayed, C. Sandor and H. Laga, "Visual analytics in Augmented Reality," 2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Adelaide, SA, 2013, pp. 1-4, 14

O. Kolesnichenko, G. Smorodin, D. Yakovleva, L. Mazelis, O. Zhurenkov and Y. Kolesnichenko, "Text Big Data Analytics: Exploring API opportunity: Internet as global storage — how to get the situation awareness from dark data," 2016 IEEE 10th International Conference on Application of Information and Communication Technologies (AICT), Baku, 2016, pp. 1-5 5

S. Su et al., "Virtual and Augmented Reality Applications to Support Data Analysis and Assessment of Science and Engineering," in Computing in Science & Engineering, vol. 22, no. 3, pp. 27-39, 1 May-June 2020. 4

S. Z. Z. Abidin, N. M. Idris and A. H. Husain, "Extraction and classification of unstructured data in WebPages for structured multimedia database via XML," 2010 International Conference on Information Retrieval & Knowledge Management (CAMP), Shah Alam, Selangor, 2010, pp. 44-49 7

Bansari Trivedi, Dr.Gokulnath K. RESEARCH ON DARK DATA ANALYSIS TO REDUCE DATA COMPLEXITY IN BIG DATA, International Education & Research Journal [IERJ], E-ISSN No : 2454-9916 , Volume : 3, Issue : 5, May 2017 19

DimitarTrajanov, Vladimir Zdraveski, RisteStojanov and LjupcoKocarev, ―Dark Data in Internet of Things (IoT): Challenges and Opportunities‖ Proceedings of the 7th Small Systems Simulation Symposium 2018, Niš, Serbia, 12th-14th February 2018 9

G. J. Lepinski and R. Vertegaal, "Unused information: Detecting and applying eye contact data in computerized healthcare systems," 2008 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Vancouver, BC, 2008, pp. 751-754 22

H. Nguyen, B. Ward, U. Engelke, B. Thomas and T. Bednarz, "Collaborative Data Analytics Using Virtual Reality," 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), Osaka, Japan, 2019, pp. 1098-1099 20

I. Horváth, "Evolution of teaching roles and tasks in VR / AR-based education," 2018 9th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Budapest, Hungary, 2018, pp. 000355-000360. 16

L. Zheng and C. Joe-Wong, "Understanding rollover data," 2016 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS), San Francisco, CA, 2016, pp. 662-667 21

S. Priyadarshy, "Big data, smart data, dark data and open data: eGovernment of the future," 2015 Second International Conference on eDemocracy& eGovernment (ICEDEG), Quito, 2015, pp. 16-16, doi: 10.1109/ICEDEG.2015.7114483. 17

Sarang Saxena, ―Dark Data and Its Future Prospects‖ International Journal of Engineering Technology Science and Research IJETSR, ISSN 2394 – 3386 Volume 5, Issue 1 January 2018 10

W. M. S. Yafooz, S. Z. Z. Abidin, N. Omar and Z. Idrus, "Managing unstructured data in relational databases," 2013 IEEE Conference on Systems, Process & Control (ICSPC), Kuala Lumpur, 2013, pp. 198-203, doi: 10.1109/SPC.2013.6735131. 8

Y. Li and S. Hou, "Methods and Techniques in Data Visualization Model," 2017 International Conference on Computer Technology, Electronics and Communication (ICCTEC), Dalian, China, 2017, pp. 71-74 18

Zhang C, Shin J, Ré C, Cafarella M, Niu F. ―Extracting Databases from Dark Data with DeepDive‖ Proc ACM SIGMOD Int Conf Manag Data. 2016;2016:847-859.12

J. Liu, T. Tang, W. Wang, B. Xu, X. Kong and F. Xia, "A Survey of Scholarly Data Visualization," in IEEE Access, vol. 6, pp. 19205-19221, 2018 3

Shunan Guo, Fan Du, Sana Malik, Eunyee Koh, Sungchul Kim, Zhicheng Liu, Donghyun Kim, HongyuanZha, and Nan Cao. 2019. ―Visualizing Uncertainty and Alternatives in Event Sequence Predictions‖. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19). Association for Computing Machinery, New York, NY, USA, Paper 573, 1–12. 1

Lahemer ES, Rad A. An Adaptive Augmented Vision-Based Ellipsoidal SLAM for Indoor Environments. Sensors (Basel). 2019;19(12):2795. Published 2019 Jun 21 6

Njeru Mwiti Kevin, FelisterMunyiWanyaga, David Kibaara, WilkisterAtienoDinda, James Kariuki Ngatia; ― Dark data: Business Analytical tools and Facilities for illuminating dark data‖ Scientific Research Journal (SCIRJ), Volume IV, Issue IV, April 2016, ISSN 2201-2796.2

R. Toasa, M. Maximiano, C. Reis and D. Guevara, "Data visualization techniques for real-time information — A custom and dynamic dashboard for analyzing surveys' results," 2018 13th Iberian Conference on Information Systems and Technologies (CISTI), Caceres, 2018, pp. 1-7. 13

D.N.Punith Kumar, Akram Pasha Insights of Mathematics for Big Data, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958,Volume-8, Issue-5S, May 2019

Gartner, "Magic Quadrant for Business Intelligence and Analytic platforms," 2015.

Gregory S. Nelson, "Business Intelligence 2.0: Are we there yet?," SAS global forum, pp. 1-10, 2010

Dr.AarushiKataria, Dr. Naveen Nandal and Dr. Ritika Malik, Shahnaz Husain -A Successful Indian Woman Entrepreneur, International Journal of Disaster Recovery and Business ContinuityVol.11, No. 2, (2020), pp. 88–93

Kumar, S. (2020). Relevance of Buddhist Philosophy in Modern Management Theory. Psychology and Education, Vol. 58, no.2, pp. 2104–2111.

Roy, V., Shukla, P. K., Gupta, A. K., Goel, V., Shukla, P. K., & Shukla, S. (2021). Taxonomy on EEG Artifacts Removal Methods, Issues, and Healthcare Applications. Journal of Organizational and End User Computing (JOEUC), 33(1), 19-46. http://doi.org/10.4018/JOEUC.2021010102

Shukla Prashant Kumar, Sandhu Jasminder Kaur, Ahirwar Anamika, Ghai Deepika, MaheshwaryPriti, Shukla Piyush Kumar (2021). Multiobjective Genetic Algorithm and Convolutional Neural Network Based COVID-19 Identification in Chest X-Ray Images, Mathematical Problems in Engineering, vol. 2021, Article ID 7804540, 9 pages. https://doi.org/10.1155/2021/7804540

Aarushi, Naveen Nandal, Parul Agrawal. AN EXPLORATORY RESEARCH IN PRODUCT INNOVATION IN AUTOMOBILE SECTOR. JCR. 2020; 7(2): 522-529. doi:10.31838/jcr.07.02.98