Chapter 3
Big Data Analytics for ICT Monitoring and Development

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Abstract The expanded growth of information and communication technology has opened new era of digitization which is proving to be a great challenge for researchers and scientists around the globe. The utmost paradigm is to handle and process the explosion of data with minimal cost and discover relevant hidden information in the least amount of time. The buzz word "BIG DATA" is a widely anticipated term with the potential to handle heterogeneous, complex, and unstructured data. We can say that big data has evolved as a monitoring tool for ICT to detect relevant patterns which were previous unknown. This chapter focuses on ICT and big data application in varied application domains. The aim is to design a framework for business data resources which gather at unprecedented pace and derive relevant information with big data analytics for better decision-making. In addition, this chapter discusses a novel framework where big data analytics is utilized as potential decision-making step for relatively better management policies.

Keywords Big data • Information and Communication Technologies (ICT) • Network analysis • Business data analytics • Decision-making

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3.1 Introduction

Data exploration has opened newly challenges for information society to develop new ways to handle data. The "Big Data" in information and communication technologies (ICTs) has evolved to provide services and hidden information which can benefit end users. The big data is a widely anticipated paradigm which has the capability to handle complex and heterogeneous nature of data that can be utilized in varied application domains. In this context, big data has been exploratory used in healthcare, agriculture, economic, sensor-based technology, mobile data network, and other ICT data to get insights of data for future decision-making [25].

The overall trend today is to detect hidden and unknown information from big data to explore new ventures. However, traditional technology was insufficient to handle and process such billion bytes of data. Big data provides a complement system to handle complex nature of data and discover hidden facts for future knowledge discovery. We can also say that big data can be leveraged with new advanced technology in ICTs [13]. Moreover, the key challenge faced is to synchronize data from various sources, which otherwise can provide inaccurate results. Hence big data can prove to be a game changer where it can applicably demonstrate the relative facts among the data gathered from various sources for decision-making. Business companies are investing billions of dollars to investigate the cause relationship among customer patterns to increase their profit margins. They need an appropriate technology which can benefit them in terms of minimal cost and delivering accurate patterns. So exploration of data is focused on big data analytics where the competitive situation is to deliver real facts and knowledge from complex data resources.

The potential of new intervene technology is to preprocess the voluminous data and extract information with respect to pace of data gathering. Thus, insights into business consumer behavior are one of the leveraged determinate factors that all leading companies want to acquire in order to attain or retain their customers. The relative factor is to meet the customer needs and determine factors which are capable of retaining customers with big data analytics. So the business market is focused on the use of new ICT-based technology which is big data analytics to overwhelm the need of today's market value.

The customer data gathered from emerging digitization technology comprises of heterogeneous and unstructured data congregated from online, shop, mall, and other sources such as a group of people with different behavioral patterns. Hence, big data can withdraw varied patterns to benefit companies to draw interference to retain their valued customers [8, 37, 40–43]. For example, customers doing online shopping express their views and sentiments while buying the products; if this data is interfaced in a proper way, one can detect behavioral pattern and cost sensitivity of a product. This information can help to monitor clear and broad view of market for decision-making. However, there exists a global shift where the customer older market research is linked with the new likes and dislikes of current customers to determine the competitive nature of products or services and create awareness patterns for organizations to have a clear picture of market so that they can dis-

semble their products with the growing need of market. This will certainly help them to identify their privilege customers and contribute to the need to align strategies that make them distinctive and benefit their customers' retaining policy. Further, we can say that ICT-based technology can gather data from various resources without the struggle to store the data with predetermined purpose and analyze this information with overwhelming strategies in tune with the needs of a business to fulfill customer needs.

The chapter is organized as follows. The next section presents the background literature review of ICT and big data potential on varied application domains. In Sect. 3.3, we describe the predictive analytics in ICT for discovery of patterns for future decision-making. Then, a novel framework is discussed utilizing big data analytics and decision-making for appropriate future management policies. We finally conclude the chapter summarizing is learning from it.

3.2 Background

Over the last decade, data has been growing at an explosive rate. As data is invariably related with digital explosion and the Internet, the challenge is to invariably utilize algorithmic technology and deploy IT-based tools to deliver known facts from big data. For example, consumer behavior patterns are changing in fast, each time a click on the Internet is recorded for likes and dislikes. The data generated each day is tremendous in nature; further the analysis of such data plays a vital role for future decision-making. Hence, the big data term is a commonly utilized term for unstructured flow of data where the focus is to detect hidden patterns with minimal amount of time. The approach of big data is to provide services in the form of analysis, where new process models can be revealed with potential knowledge network.

The big data in ICT can be illustrated with the ever expanding use of the Internet, mobile phones, electronic health care, geographic information data, scanner data, and other data resources that are applicable to varied application domains [1, 27, 28, 30]. In earlier times, in the traditional-based system, the data was getting collected from specific resources which tended to be manual in nature. However, the advent of the Internet has proved to be a game changer and has opened gates for electronic data system. The growth in ICT has potentially driven the society to digital explosion. For example, traditionally when a customer used to buy products from shopping areas on daily basis, there was never a check on the amount of items bought by a specific customer nor were the items ever categorized on quality and productivity. Further, today's customer behavior is integrated with the Internet buying and selling over the Internet. The data collected is then decodified to understand customer needs across the globe. The information is not just about the customer buying trends but business can also categorize the customer in accordance to their sales in correspondence to

their sociodemographic factors. Hence, organizations are earning millions of dollars while retrieving hidden facts and knowledge from complex and heterogeneous nature of data.

We can say that there is a revolution in ICT with big data where small or big organizations' day-to-day functionality is driven by computers [2–8]. The database gathered each day from varied resources, if analyzed or predicted, can deliver true instances for future decision-making. Moreover, business organizations are in era of online operation where everyday several customer and financial data is shared through the Internet. For example, big organizations are compiling their inventory system, financial expenditures, tax fillings, employee personal evaluation, and regulatory activities with online-based portals to analyze the cross-sectional profits and reduce cost to acquire maximum benefit for end users.

Further, we can say that data is being gathered for years, but why there exists more concern for knowledge now? The answer is digitization or ICT where the scope has increased from higher to lower. Obliviously, the Internet has expanded the vision of society, the customer behavior and trends have changed, and mostly all the developed and developing nations have acquired online buying and selling portals, which itself is a global shift to new IT-based interventions. This has led to insights for analytics where the scope is to discover hidden effective and efficient patterns for knowledge discovery.

A major change witnessed is that data has expanded with an exponential rate where the challenge among the researchers and practitioners is to optimize tools which can handle and process such large databases. However, the evolution of ICT has redefined the global scenario; earlier data was gathered in few bytes which could easily be processed or handled by traditional or statistical tools. But, the evolution of Internet or digitization has seen an exponential increase in data from a few bytes to millions of bytes every day. In such cases, we require optimized technology to process, store, and analyze data for effective and efficient knowledge discovery for future decision-making.

For instance, nowadays, the complex and heterogeneous data is available which is recorded from various resources. We can say that data in hospital-based system consists of patient healthcare records, scanned images, and sensor-based data, which comprises of electric cardio gram (ECG), financial data, and location-based data. These databases are distinctive in nature and require huge number of correlations to determine hidden facts and knowledge from the same. For example, if we have the entire database available for each time a patient visits the hospital, it can benefit healthcare practitioners to determine the patient behavior and predict which vaccination can benefit more. Besides, the data can also provide information on what drugs the patient is allergic to and other such facts that can help doctors prescribe medications accordingly. So we require optimized tools which can make correct prediction when dealing with real world data.

Eventually, the socio-behavior is an amazing scale of modernized datasets generated through online consumer buying patterns. Data collectively recorded comprises of varied observations which show most purchased and disliked social network connections, complete shopping history, and other background data. If

this data is analyzed, it can provide a wealth of information on customer behavior and benefit the organization to retain their valued customers by bestowing them with great deals and offers in accordance with their likes and dislikes.

Although, big data is a term for any data that is more than a few bytes and is difficult to be handled due to its complex and unstructured features. Certainly, big data poses a significant challenge among the researchers to conceive and reform an approach which can grip varied application domains [14, 15]. The confrontation is analysis, which is the major concern while retrieving some specific patterns from large-amount databases [9–15]. Data analytics is gaining momentum with associated challenges to discover novel facts from large-scale databases.

We can certainly demonstrate that big data is the latest buzz in the market. As we know, data is generated by all companies, but significantly there occurs a global shift for data digitization [24, 27, 29, 32]. Big data offers a constructive way to handle information with lower cost and effectiveness and analyze it for future effective knowledge discovery. Big data reflects concern about volume, variety, and velocity, which are gathered through new ICT interventions. The big data is significantly divided into four categories which are also known as 4Vs:

Volume There is tremendous increase in digitization at all spectrums from varied resources. The data comprises of administrative data, financial data, healthcare data, transaction-based data, socio-networking, organizational data, and other activities involved by end users utilizing ICT-based tools. The traditional tools utilized for computational analysis for volume of data are not viable. Most companies try to store their data for convenient report generation.

Velocity The speed at which data is being generated is explosive. For instance, traffic management data, mobile communication, imaging and sensor-based data, GIS, and streaming-based data tend to be major sources which are being generated at an explosive speed. However, big data and developed ICT tools have brought real-time handling, but certainly there is great expansion of data that requires concerns for gaining knowledge for future discovery. The challenge is to handle big data with vast volume to achieve insight of data with advanced predictive analytics techniques to discover novel hidden patterns. Big data provides a recommended technological domain where the emphasis relies on handling volumes of data.

Variety The growth in ICT and digitization has given rise to a number of sources for gathering data. We can say that data resources may be structured and unstructured due to availability of data in different formats which may include audio, video, text, sensor, imaging, and streaming. To gather information from varied sources to compile to big data, there is considerable requirement of valid assessable tools which can benefit decision-makers for policy making. Hence, big data meets the challenges to handle the data with the unknown resources and predicts the relevant information as and when required.

Veracity As the volume of data is increased with varied data streams, the need is to extract authenticity of data with certain and uncertain sources. The analysis of data must be done keeping in view the sources and the authentication from various resources.

The traditional tools available tend to be unsuited to handle uncertainty among the resources; hence big data analytics produces a viable technology to make decision-making utilizing the heterogeneous nature of data. These technological advances will certainly benefit different application domains to generalize data and discover information which is hidden due to unconventional tools and complex nature of data.

Value Another V is value that is generated with respect to socioeconomic development that occurs due to big data. There are several transaction-based data that are generated during the course of a transaction process which can reveal certain facts for decision-making. For example, if consumer wants to take a loan, during the course of entire verification, the phone calls made, transaction process, and other information can lead to discover information which can benefit decision-makers to relatively identify various facts and knowledge related to the overall process. The subset of data generated during the course of action with socio-behavioral facts which are generated is variably true and can really benefit decision-makers. This improved technology and services can assist to extract value from vast explosion of data to determine actual knowledge. In addition, big data has proven unprecedented development in varied application domains to discover knowledge and hidden facts from varied data streams with high volume, variety, and varsity of data. The knowledge driven out from big data analytics is not informatics but cost-effective; both rural and urban development organizations are utilizing the exceptional powers of big data to improve their services and forefronted use of the same for extraction of information and operational domains to increase time utilization. We can also say that big data is widely opted due to various services provided which includes monitoring and its role for timely delivering the hidden facts which can enhance the future policy making for socio well-being.

3.3 Predictive Analytics for ICT

The growth of ICT offers enormous benefits to developed as well as developing nations for future decision-making. The data captured through ICT is growing at an unprecedented speed to confront researchers and scientists to develop automation tools to discover knowledge from big data. Big data itself intensifies data captured through ICT-based technology. The major source of big data is through ICT which includes Internet, telecommunication, social economic web portals, mobile data, and others. The ICT development has exponentially embarked the growth globally, producing heterogeneous and complex nature of data [21, 24, 26, 31]. In addition, providing policy makers to discovery has new instantiated tools for predictive analytics. Collectively, ICT-based predictive analytics can prove exemplary benefits to gain insights of data for future decision-making.

Big data and ICT go together where data is generated by ICT tools and handled by big data optimization tools to discover hidden knowledge and information. The most remarkable use of predictive analytics is in business processes to determine

the outcomes for current models. The technology advances such as predictive analytics with ICT are proving to benefit with less cost and higher efficiency. For example, online web portals Amazon, Snapdeal, Flipkart, Google, Twitter, and others are availing consumer information, both before prior purchases and after purchases [11, 36]. This information proves to be vital to discover the usage patterns with socio-behavioral analysis to predict models for relevant customer to upgrade them to substantial offers. In addition, online web portal data, if analyzed properly, can facilitate to discover risk factors and fraud customers which prove to be set back for companies' growth. This information can widely be anticipated at a global platform to enhance overall net profit for development purposes.

The application of predictive analytics approach can be utilized in healthcare application domain where the data is generated, while patient is admitted during the stay in hospital for a specific cause. Further, the online web databases can be maintained globally to deliver predictive models and improve healthcare cost [19–23]. Specifically, risk scores can be identified, for example, which patient is at risk of disease due to specific drug or chances of survival for definite disease. This will certainly benefit healthcare practitioners with a whole set of information relating to insurance policy, pharmacy genetics, financial services, and fraud detection for future median diagnosis. An algorithmic-based Palo Alto company is among the million dollar companies whose major role is to develop algorithms to determine terrorist's threats using communication devices and other related data.

Further, big data analytics also has provision to detect the socio-behavior of patient to discover fraud patients in respect to financial constraints. Similar approach can also be utilized to discover user behavior for credit card handling. The customer financial accounting data may be investigated by banks based on scoring and transactions to enquire about the rational status of user or to determine whether the user pertains to an effective account or not. These policies, when implemented with backbone of predictive data analytics, provide fruitful decision-making for business organizations.

There exist considerable amount of work on predictive analytics using statistical and machine learning platform to discover trends from big data [38]. The widely used techniques for analytics include classification where the emphasis of study relies on discovering patterns in respect to specific class; clustering is mostly utilized when the class is not specific and generates visualized patterns in respect to similarity measurements, for example, if we want to find the similarity between the consumer behavior in respect to socioeconomic features which include age, gender, and location specific, then we can utilize several clustering techniques such as K means, Grid-based, hierarchical, and density-based, as per outcomes required [18, 35, 37, 40]. In addition, association rules are used in empirical studies to relate the consumer buying patterns, in context, for example, if the consumer is buying a shirt what all are the associated other purchases or likes made by him or her. This will help to detect the consumer buying patterns to determine valid offers to retain him or her as the valued customer. In a similar way, outlier detection is widely optimized to discover consumer patterns for credit card fraud detection techniques, where the consumer's financial details are dealt

with an onset implemented policy to detect which customer may have high risk factor of defaulting. So, it can benefit a bank organization to investigate the customer and approve or reject credit card accordingly.

3.4 Decision-Making Through ICT and Big Data Analytics

Decision-making is of utmost priority in a management plan to gather maximum profits for stakeholders and organizations. The management plan should be able to encounter all the varied possibilities to enlarge the current scenario with maximum profits to target. The decision predictive analytics should be marked in the management plan to discover trends to get insights of data. As there exist subsisting amount of challenges to understand and deliver services to consumer, there is a constant need to utilize new innovated ICT-based technology, which is able to detect hidden patterns from big data.

A novel decision-making framework is discussed in Fig. 3.1 where ICT-based technological advances can be occupied to discover hidden patterns from big data. The bottom of framework discusses about business data resources which can be gathered at an unprecedented pace, and the nature of data can be heterogeneously collected through logistics, online portal, transactional databases, supply chain management, insurance-based data, consumer data, management data, RFID data, spatial data (location based), and other resources which are high dimensional and unstructured [3, 12, 16, 40]. As we know, the data is in vast volumes; hence, the next question is to extract relevant information from such big data [17]. So application domain relies on what information needs to be extracted as per management plan or identifies the factors which need to be closely related or conferred to gather maximum profit to organization.

Furthermore, the management plan should be attained with previous decisions in correspondence to new decision-making to deliver exact knowledge for future benefits of an organization. The management plan is to rebuild its policies with pertained data analytics for financial risk. After extensive knowledge, the management can decide which all patterns can be extracted during analytics to discover hidden trends which can ensure maximum cost efficiency and provide services to end users. The big data analytics utilize high-end advance technology to deliver nodal factors which can potentially deliver benefits to decision-making bodies [33–35]. After the factors are analyzed, the decision-making body relates various results with ongoing policies and makes changes to management policy with new patterns detected to benefit the stakeholders and consumers for retaining them as valued customers.

The building block of any organization is its management and decision-making team. The decisions should not be hassled with traditional technology as this can generalize data and infer wrong patterns which can highly impact the organizational growth. The new intervened ICT-based technology with big data analytics has opened wide scope and benefited organizations to reap rich dividends. The attainment of predictive analytics from the last decade has opened new ventures for an organization which certainly has revealed to attain them better policy making.

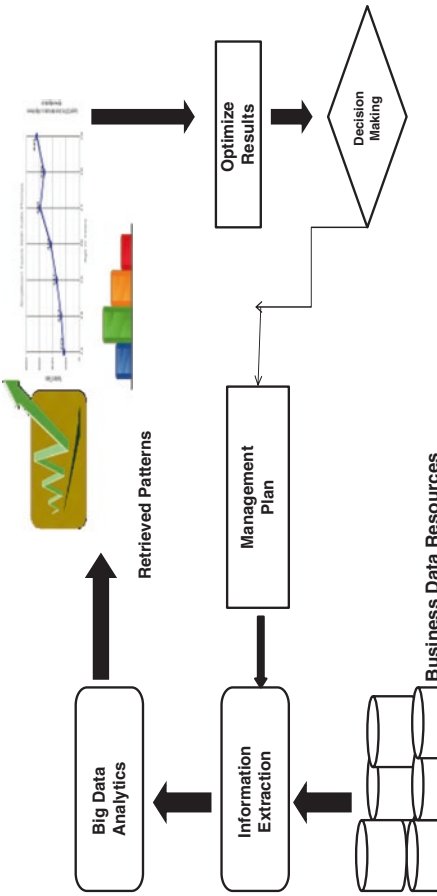

Fig. 3.1 Framework for data analytics in management plan

In addition, big data analytics with business ventures has helped organizations to deliver maximum cost-effective and consumer-retaining policies which are potentially proven to optimize the current scenario. The transition has occurred where decision-making in current management policies has extensively utilized big data to determine factors for extensive growth.

3.5 Conclusion

The current big data has potentially proven beneficial to complement the needs of organizations with prior information to provide insights of data for a channelized decision-making. In particular, the ICT technology is providing challenges to researchers and practitioners to develop new synthesized tools to handle bulk data generated in structured and unstructured formats. In addition, this chapter discusses a novel framework where big data analytics is utilized as potential decision-making step for relatively better management policies.

The main application of ICT is to produce insights of information and to develop utmost technology for analytics to discover hidden information from big data. In particular, ICT has increased the growth of digitization globally, which itself is producing millions of bytes each day. Paramount technological capabilities are required to enhance the digitization and algorithmic powers to attain necessary tools which can handle and process big amount of data. Big data analytics itself is a composite term which has grown in the last few years. More and more organizations are now being forced to adopt big data analytics to remain competitive in the market. Big data researchers are impounding enough efforts to mainstream technology in developing nations so it can benefit all end users with maximum benefits.

Many organizations are working to develop models from data resources with analytics approach for developmental purposes. These organizations are taking advantage of the analytical approach to detect customer patterns for greater understanding of consumer knowledge and incorporating in their product cycle for greater benefits. Big data analytics plays an important role for monitoring of ICT, where it proliferates a constant need to discover hidden facts and knowledge from big data. Certainly, integrating data from various sources is a need of today's time to explore knowledge for future technological interventions.

We can say that environmental organizations, when they share data with hospital-based systems, will be able to generate various causes or alarms which are proving to be cause or prognosis of disease. There exists a constant scope to explore variable factors and technological tools to handle and process big data. Further, we can say as big data moves toward more advance technology, it will assist users and scientists around the globe for knowledge extraction.

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References

1. Bakhshi, H., Bravo-Biosca, A., & Mateos-Garcia, J. (2014). *Inside the Datavores: Estimating the effects of data and online analytics on firm performance*. London: NESTA.
2. Brynjolfsson, E., & McAfee, A. (2012, October). Big data's management revolution. *Harvard Business Review*, 90, 61–68.
3. Brynjolfsson, E., Hitt, L. M., & Kim, H. H. (2011). Strength in numbers: How does data-driven decision making affect firm performance? Social Science Research Network (April 22, 2011). Available at SSRN: https://ssrn.com/abstract=1819486 or http://dx.doi.org/10.2139/ssrn.1819486.
4. Burt, R. S. (1992). *Structural holes: The social structure of competition*. Cambridge: Cambridge University Press.
5. García-Muñiz, A. S., & Vicente, M. (2014). ICT Technologies in Europe: A study of technological diffusion and economic growth under network theory. *Telecommunications Policy, 38*, 360–370.
6. Colombo, M. G., Croce, A., & Grilli, L. (2013). ICT services and small businesses' productivity gains: An analysis of the adoption of broadband Internet technology. *Information Economics and Policy, 25*(3), 171–189.
7. Abreu, R. (2013). Big data and Huawei Chile. Presented at the presented at Complexity, Innovation and ICT, UN ECLAC, Santiago, Chile.
8. Boyd, D., & Crawford, K. (2012). Critical questions for big data. *Information, Communication & Society, 15*(5), 662–679. doi:10.1080/1369118X.2012.678878.
9. Brynjolfsson, E., Hitt, L. M., & Kim, H. H. (2011). Strength in numbers: How does data-driven decisionmaking affect firm performance?. SSRN eLibrary. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1819486
10. Chen, C. L. P., & Zhang, C.-Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on big data. *Information Sciences, 275*, 314–347.
11. Choi, H., & Varian, H. (2012). Predicting the present with Google trends. *The Economic Record, 88*, 2–9. doi:10.1111/j.1475-4932.2012.00809.x.
12. García-Muñiz, A. S., & Ramos, C. (2015). Input-output linkages and network contagion in Greece: Demand and supply view. *Applied Econometrics and International Development, 15*, 35–60.
13. Institute of Prospective Technological Studies. (2015). *The 2014 predict report: An analysis of ICT R&D in the EU and beyond*. Seville: Institute of Prospective Technological Studies.
14. Driscoll, K. (2012). From punched cards to "Big Data": A social history of database populism. *Communication, 1*(1), 1. http://scholarworks.umass.edu/cpo/vol1/iss1/4
15. Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Hung Byers, A. (2011). *Big data: The next frontier for innovation, competition, and productivity*. McKinsey &Company. http://www.mckinsey.com/Insights/MGI/Research/Technology_and_Innovation/Big_data_The_next_frontier_for_ innovation
16. Noormohammad, S. F., Mamlin, B. W., Biondich, P. G., McKown, B., Kimaiyo, S. N., & Were, M. C. (2010). Changing course to make clinical decision support work in an HIV clinic in Kenya. *International Journal of Medical Informatics, 79*(3), 204–210. doi:10.1016/j.ijmedinf.2010.01.002.
17. Fayyad, U. M., Haussler, D., & Stolorz, Z. (1996). KDD for science data analysis: Issues and examples. In *Proceedings of 2nd international conference on knowledge discovery and data mining*, Portland, Oregon (pp. 50–56). AAAI Press, Menlo Park.
18. Koperski, K., Han, J., & Stefanovic, N. (1998). An efficient two-step method for classification of spatial data. In: Proceedings of the 8th symposium on spatial data handling (pp. 45–54). Vancouver.
19. Kolatch, E. (2001). *Clustering algorithms for spatial databases: A survey University of Maryland*. College Park: Department of Computer Science.
20. Kaufman, L., & Rousseeuw, P. J. (1990). *Finding groups in data: An introduction to cluster analysis*, *Series in applied probability and statistics*. New York: Wiley-Interscience.
21. Kaur, H., Chauhan, R., & Alam, M.A. (2012). SPAGRID: A spatial grid framework for medical high dimensional databases. In *Proceedings of international conference on hybrid artificial intelligence systems*, HAIS 2012, Springer, (Vol. 1) (pp. 690–704).

22. Kaur, H., Chauhan, R., & Alam, M.A. (2010). An optimal categorization of feature selection methods for knowledge discovery. In: Q. Zhang, R. Segall, & M. Cao (Eds.), *Visual analytics and interactive technologies: Data, text and web mining applications* (pp. 94–108). IGI Publishers, USA.
23. Kaur, H., Chauhan, R., & Aljunid, S. (2012). Data mining cluster analysis on the influence of health factors in Casemix data. *BMC Journal of Health Services Research, 12*(Suppl. 1), O3.
24. Robinson, L., Cotten, S. R., Ono, H., Quan-Haase, A., Mesch, G., Chen, W., & Stern, M. J. (2015). Digital inequalities and why they matter. *Information, Communication & Society, 18*(5), 569–582.
25. Smith, M. L., Spence, R., & Rashid, A. T. (2011). Mobile phones and expanding human capabilities. *Information Technologies and International Development, 7*(3), 77.
26. Kleine, D. (2013). *Technologies of choice?: ICTs, development, and the capabilities approach*. Cambridge, MA: MIT Press.
27. Zittrain, J., & Palfrey, J. (2008). Internet filtering: The politics and mechanisms of control. In R. Deibert, J. Palfrey, R. Rohozinski, & J. Zittrain (Eds.), *The practice and policy of global Internet filtering* (pp. 29–56). Cambridge, MA: Massachusetts Institute of Technology Press.
28. Tongia, R., & Wilson III, E. J. (2011). Network theory: The flip side of Metcalfe's law: Multiple and growing costs of network exclusion. *International Journal of Communication, 5*, 17.
29. Barbosa, B., & Amaro, F. (2012). Too old for technology? How the elderly of Lisbon use and perceive ICT. *The Journal of Community Informatics, 8*, 1.
30. Wellman, B., Hasse, A. Q., Witte, J., & Hampton, K. (2001). Does the internet increase, decrease, or supplement social capital? *American Behavioral Scientist, 45*(3), 436–455.
31. Shim, D. C., & Eom, T. H. (2009). Anticorruption effects of information communication and technology and social capital. *International Review of Administrative Sciences, 75*(1), 99–116.
32. McKinsey. (2011). *Big data, the next frontier for innovation, competition and productivity*. New York: McKinsey.
33. Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business Intelligence and analytics: From big data to big impact. *Management Information Systems Quarterly, 36*(4), 1165–1188.
34. Beyer, M. A., & Laney, D. (2012). *The importance of 'big data: A definition*. Stamford: Gartner. http://www.gartner.com/technology/research/big-data.
35. Chen, M. S., Han, J., & Yu, P. S. (1996). Data mining: An overview from a database perspective. *IEEE Transactions on Knowledge and Data Engineering, 8*(6), 866–888.
36. Lin, J., & Dmitriy, V. R. (2012). Scaling big data mining infrastructure: The twitter experience. *SIGKDD Explorations, 14*(2), 6–19.
37. Wu, X., Wu, G.-Q., & Ding, W. (2014). Data mining with big data. *IEEE Transactions on Knowledge and Data Engineering, 26*(1), 97–107.
38. Kaur, H., Chauhan, R., & Wasan, S. K. (2015). A Bayesian network model for probability estimation. In Mehdi Khosrow-Pour (Ed.), *Encyclopedia of information science and technology*, 3rd ed, (pp. 1551–1558). Accessed 10 Dec 2014. doi:10.4018/978-1-4666-5888-2. ch148 (2014).
39. Chauhan, R., & Kaur, H. (2015). Big data application in medical domain. In *Computational intelligence for big data analysis: Frontier advances and applications*, *Adaptation, learning, and optimization* (Vol. 19, pp. 165–179). Switzerland: Springer International Publishing.
40. Chauhan, R., & Kaur, H. (2015). SPAM: An effective and efficient spatial algorithm for mining grid data. *Geo-intelligence and visualization through big data trends*. *IGI Global, 2015*, 245–263. Web. 9 Sep. 2015. doi:10.4018/978-1-4666-8465-2.ch010.
41. Kaur, H., & Tao, X. (Eds.). (2014). *ICTs and the millennium development goals: A United Nations perspective*. New York: Springer.
42. Lechman, E., & Kaur, H. (2016). *Social development and ICT adoption. Developing world perspective*, *GUT FME working papers series A, No3 /2016(33)*. Gdansk: Gdansk University of Technology, Faculty of Management and Economics, Gdansk, Poland.
43. Lechman, E., & Kaur, H. (2015). *Economic growth and female labor force participation – verifying the U-feminization hypothesis. New evidence for 162 countries over the period* 1990–2012. *Economics & Sociology, 8*, 1.