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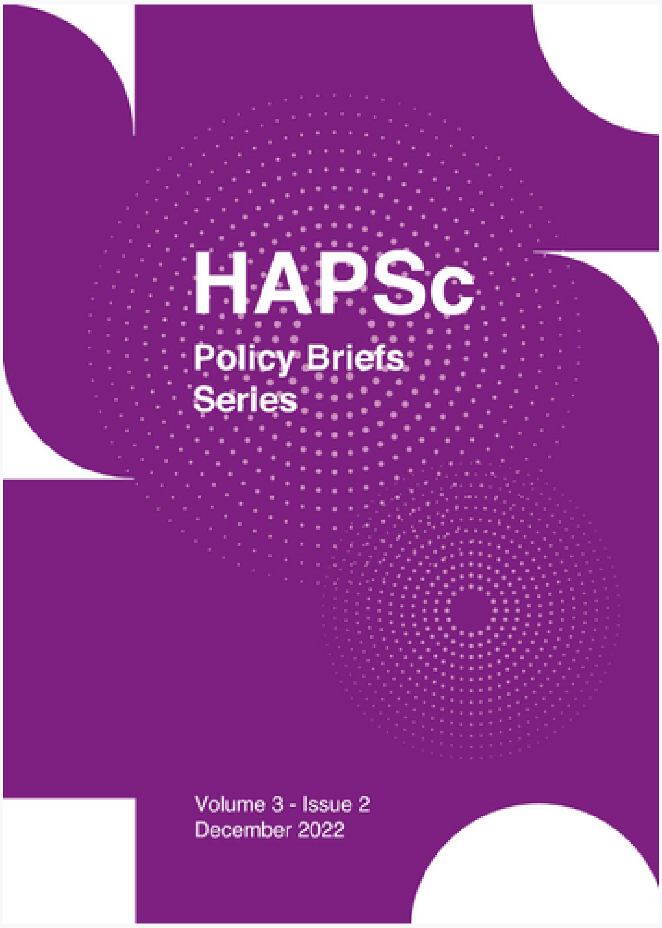

Big Data, Sentiment Analysis, and Examples during the COVID-19 Pandemic

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Big Data, Sentiment Analysis, and Examples during the COVID-19 Pandemic[1]

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Abstract

Applied research in Big Data has gained popularity and is already transforming corporations, public sector, health care and subsequently everyday life. Big Data are being analysed for a variety of reasons, e.g., predict Brexit negotiating outcomes, optimise operations in agriculture, map and analyse human mobility trends under non-pharmaceutical interventions during the recent pandemic. The period of the COVID-19 pandemic has been characterised also by an 'infodemic', meaning an overabundance of both good and bad information. This information needs to be managed effectively as it can yield valuable insights when analysed. In this paper the terms of Big Data, Geospatial Big Data and Sentiment Analysis are presented along with selected cases, from the international literature, of the use of Big Data and analytics during the COVID-19 pandemic.

Keywords: Big Data; Spatial Big Data; Sentiment Analysis; COVID – 19.

Introduction

Applied research in big data has gained popularity and tends to be driven by organisations, researchers, governments and academia that explore methodologies to capitalise on big data, gain economic benefit from revealing relationships, trends and patterns, and not only (Diareme and Tsiligiridis, 2018), e.g. commerce user-generated content about brands is an important source of Big Data that can be transformed into valuable information (Kauffmann et al., 2019). In addition, the rise of Internet of Things (IoT) along with the Internet of Everything (IoE) denotes the need for Big Data solutions. Smart objects connected to the IoE enable researchers, for example, to improve agriculture and food security, optimise logistics, identify and contain fatal infections, decrease pollution in some of the world's largest cities (Zhan et al., 2022).

Under the above concept all devices such as smartphones, transportation facilities, public services, and home appliances are used as data creator devices, and data comes in heterogenous formats. Data can come from structured data sources, semi-structured or unstructured, in addition data can also be spatial. Moreover, the size of the data generated is calculated not in terabytes but in Petabytes,

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Zetabytes or even Brontonbytes and Geopbytes. One source of Big Data is data generated in social media as well as comments posted online. Human beings share their good or bad opinions about subjects, products, and services through internet and social networks, and the ability to effectively analyse this kind of information is seen as a key competitive advantage to better inform decision (Alaoui & Gahi, 2019). Examples of Big Data analysis range from the prediction of Brexit negotiating outcomes (Georgiadou et al., 2020) to green supply chain management (Q. Zhang, Gao, & Luqman, 2022) and, along with artificial intelligence, help transform Healthcare Management (Efthymiou et al., 2020), and advance pandemic preparedness and response (Tacconelli et al., 2022)

Big Data

For Big Data no single definition exists, and although the term at least as a phenomenon is not new (Smirnova et al., 2018) it has been used since the mid-90s, and was initially associated with size/volume of data (massive data). Today the term refers to datasets that are too large or too complex (Cobb et al., 2018) to be handled by traditional technologies. Some important properties have been described such as the 3Vs (Volume, Variety and Velocity)(Mir et al., 2021), and 5Vs (Volume, Variety and Velocity, Veracity, Variability). Other additional Vs have been proposed, such as Verification, Validation, and Visualization for spatial data, and although their value is debatable, they do touch on important concepts related to the entire pipeline of big data collection, processing and presentation (Diareme and Tsiligiridis, 2018).

Since no international benchmarks for the above exists, working with Big Data means that, depending the case, traditional technologies do not suffice, in cases lack scalability, flexibility and/or performance (Oussous et al. 2017), for the extraction, collection from many distributed sources, store, scrub, load, and in general management of the data needed. Today it is typical to see big datasets being processed, as per case, by Artificial Intelligence algorithm, supervised or unsupervised machine learning algorithms to ultimately extract new knowledge. Frequently we also see terms such as “smart house”, “smart city”, “smart agriculture”, and in general smart information systems that combine Big Data and Artificial Intelligence (Mark, 2019).

In addition to the above, spatial computing is becoming significantly important with the proliferation of mobile devices, location-awareness, and not only. Geospatial data primarily revolves around the spatial analysis and classification of events, objects, or phenomena having an element of embedded location (Mir et al., 2021). Geospatial Big Data (GBD) can be broadly defined as data sets that include locational, spatial information, as well as map features, and that exceed the capacity of widely available hardware, software, and/or human resources (J. G. Lee & Kang, 2015; S. Li et al., 2016).

Analysing GBD can have a positive effect in many various fields, from environmental protection to the effective control of self-driving cars (S. Shang et al., 2021). It should be noted that for many scientists, spatial data, under cases, were all along big data. Since much of the data in the world can be georeferenced (S. Li et al., 2016), and since today geospatial data acquisition is implemented in everyday used devises, leading to the augmentation of the volume of data available, the effective management, and visualisation of such data is very important. Moreover, rapid advancements in technologies have resulted in new sensors and large volumes of geospatial data that, so far, have not been fully exploited (Riswantini et al., 2021). The massive Point of Interest Data provided by online platforms, e.g. Baidu (Y. Zhang et al., 2019), Google, OpenStreetMap enable scientists and organisations from various fields to experiment with these technologies and spatiotemporal models.

Challenges concerning Big Data include extract-load-transform methodologies, management of the data, cleaning of the data, need for novel processing and decision-making algorithms and interdisciplinary cooperation depending on the case or field of application. In general, the steps of Cleaning, Aggregation, Encoding, Storage and Access, that we also see in traditional data management, are present in the case of Big Data but are more difficult to deal with because of the complexity of the nature of Big Data. The recent popularity of Big Data has led to the development of several systems and services and the extension of pre-existing ones, open and proprietary ones (Diareme and Tsiligiridis, 2018).

It should be noted that there is an ongoing dialogue on human rights, the protection of the people's privacy and security, the need for data anonymisation and not only, as well as security of infrastructure. Important topics in this dialogue are also the ownership of data, bias of data sets, westernisation of data and the digital divide and the need for equal representation of all people from all backgrounds into big data sets (Mantelero, 2018), e.g. gender balance in machine learning datasets is important to stop perpetuating gender ideologies that negatively affect models that have gender as a parameter (Efthymiou et.al., 2020b). It should be noted at this point that the value deriving from the analysis of Big Data is related, also, to the complexity and accuracy of the models and of the algorithms used. However, such a technical analysis is outside of the scope of this opinion paper.

Big Data and Sentiment Analysis

Nowadays, more and more organizations need to handle and analyse a big volume of opinionative text data from various Internet sources. This kind of data is referred in research as User Generated Content (UGC). From a commercial point of view, the UGC is a positive or a negative statement made by consumers about a product, service, or a whole company, which can be available to a multitude of people and institutions via the Internet (Liapakis et al., 2020). It is notable that previous researches have shown that the UGC is more reliable to consumers compared with the traditional methods of communication (Chong et al., 2016; Liapakis et al, 2020). The problem that is created is that the involved companies or other stakeholders cannot analyse all the UGC that is produced due to the large volume and the diversity of the information (Liapakis et al., 2020). Another problem is that the vast majority of UGC does not consider the rules of spelling, syntax, and grammar (Kim et al., 2004) and this creates many difficulties in understanding and analysing customers' big data. Automatic processing of UGC still represents a challenging task (Sanguinetti et al., 2022).

The above problem can be approached with the Sentiment Analysis (or Opinion Mining). This methodology utilizes Natural Language Processing (NLP), Information Retrieval (IR), Computational Linguistics and Machine Learning (ML) techniques for extracting subjective information from source materials (Liapakis et al., 2020). It is a new field of research in Informatics, which uses modern techniques for mining and analysing a large amount of unstructured opinionative text data that is, among others, continuously produced in social media networks. The main purpose of this methodology is to classify the UGC into two polarities: Positive or Negative.

Sentiment Analysis relies on two types of techniques, i.e., machine learning and lexicon-based. Machine learning techniques are divided into supervised and unsupervised approaches. There is a large amount of literature work dealing with the above approaches. Some well-known supervised approaches are the Naïve Bayes, the Support Vector Machine, and the K-Nearest Neighbours (KNN). On the other hand, some known unsupervised machine learning approaches are the Latent Dirichlet Allocation (LDA) and the probabilistic Latent Semantic Analysis (pLSA). These approaches are quite consuming only in particular circumstances (e.g. instances that evaluate only one factor) and in most cases are implemented easily (Liapakis et al., 2020). The methodology is also applied in three levels: document-level, sentence-level, and aspect-level. The document-level is recommended in cases that a document expresses opinions only for an entity (product, service etc.). The sentence-level is recommended in cases that a sentence expresses a single opinion about an entity and from only one person. The aspect-level which is called also entity or feature level detects the sentiment for the aspects of an entity.

Big Data and COVID-19 related analysis

Since early 2020 the COVID-19 pandemic caused by SARS-CoV-2, is affecting the entire globe impacting and profoundly changing life. Furthermore, the spread of the COVID-19 global pandemic has generated an extraordinary volume of data, thus the term 'infodemic' has been used, e.g. individuals frequently express their views, opinions and emotions about the events of the pandemic on Twitter, Facebook, etc. (Xu et al., 2022), and create the need to manage and monitor these data in order to obtain relevant information (Piccarozzi & Aquilani, 2022) as well as to manage the changing needs of many economic sectors. Moreover, for COVID-19 pandemic no past observations could be used to provide a relevant signal about its potential economic (Barbaglia et al., 2022), and not only, impact.

Bellow we present selected examples of the use of Big Data as well as Sentiment Analysis during the COVID-19 pandemic. For an extensive list of publications and additional areas of applications, to the ones mentioned bellow, the interested reader is referred to Alsunaidi et al. (2021), Haafza et al. (2021) and Zhang et al. (2022). Shi et al. (2021) analysed massive CT lung image among COVID-19, CAP, and nonpneumonia subjects in order to improve understanding of COVID-19. Qiu et al. (2020) used internet search data to investigate symptom characteristics of COVID-19. For additional information on how big data and epidemiological data can be used to help get a better understanding of COVID-19 the interested reader is also referred to Leung et al. (2020).

Azzaoui et al. (2021) proposed a Social Network Service Big Data Analysis Framework for COVID-19 outbreak prediction in smart sustainable healthy city, where Twitter platform is adopted. They analysed over 10.000 openly shared tweets of USA users using NLP. Data were collected during a two months period from August 1, 2020 until September 30, 2020. According to the authors the method proposed is able to predict the next COVID-19 outbreak and related hotspots 7 days earlier, more or less, than the government authorities. Other researchers, e.g. X. Li et al. (2020), have analysed big data to improve the predictability of COVID-19. Galetsi et al. (2022) identified several Big Data Analytics and artificial applications developed to deal with the initial COVID-19 outbreak and the containment of the pandemic, along with their benefits for the social good.

Hu et al. (2021) took a big data driven approach to analyse mobile device location data (spatial data) of over 150 million monthly active samples in the United States. According to the authors the study successfully measures human mobility with three main metrics at the county level: daily average number of trips per person; daily average person-miles travelled; and daily percentage of residents staying home. Lu et al. (2021) retrieved park visit-related Instagram posts published in the four cities in Asia between December 16, 2019, and March 29, 2020 and found that there is a 5.3% increase in the odds of people using greenspaces for every 100-case increase in weekly new cases. Rice and Pan (2020) analysed park visitation as important to maintaining wellbeing during the COVID-19 pandemic and examine factors influencing changes in park visitation. The data used derived from the

Google's COVID-19 Community Mobility Reports as well as available park mobility data from 97 countries in the Western region of US. Shang et al. (2021) explored the user behaviors and environmental benefits of bike sharing. An additional notable example of both online and offline data is the Early AI-supported Response with Social listening of the World Health Organisation (EARS). EARS is using NLP and machine learning in order to analyse millions of opinions every month, structure them into categories and intents, so that actionable insights can be produced based on how public conversations are evolving every day (World Health Organization, 2021). Lately, several studies have been published that explore COVID-19 vaccination hesitancy using sentiment analysis and data from social networks. For such cases the interested reader is referred to (Xu et al., 2022) and Qorib et al. (2022). In the latter publication, apart from the proposed methodology, a comparative study of 14 publications on COVID-19 vaccine Sentiment Analysis is presented.

During the pandemic, data from social media have also been used for supply chain management. Other studies also address maintaining social distance in real time using image processing (Melenli & Topkaya, 2020), the development of COVID-19 Surveillance Dashboard (Peddireddy et al., 2020), detecting illicit product sales (Mackey et al., 2020), and retail analytics from which organisations can make decisions to anticipate the COVID-19 effects, specifically, to produce production possibility curve, reduce shortage and avoid surplus using demand and supply curves, and detect current economic conditions (Sharma et al., 2021).

Conclusions

Findings from the international literature suggests that governments and policy makers can benefit from analysing Big Data and UGC. Sentiment Analysis can be used as a real-time tool by policymakers and organisations who are always in need of information to collect input and identify citizens'/customers preferences, trends, and needs. UGC can reveal the range of society’s preferences and possibly advocate distinct policy and decision-making paths (Georgiadou et al., 2020). Governments have begun to use large datasets mined from social media to identify patterns of individual and group sentiment that may reveal, among others, the degree to which they support or oppose their policies. This is similar to businesses, which have been integrating customer comments expressed online into new product creation. (Riswantini et al., 2021).

It has been highlighted that during the pandemic, policymakers need short-term predictions and nowcasts of the current state of the economy to design timely policy actions and assess the success of various activities in mitigating the pandemic's negative effects (Barbaglia et al., 2022; Ferrara et al., 2022), in protecting societal well-being, and also to have a better understanding of citizens evolving concerns and information needs (World Health Organisation, 2021). Big Data have become an important support system in dealing with global healthcare crisis as well as a tool for economic sustainability, and social well-being during period of crisis. Participatory social media data as well as other spatial data have been in the centre of the attention.

The analysis of Big Data, enables the development of prediction models and analytical tools for a variety of applications; as presented. The added value deriving from adopting – implementing such analytical tools and models has become apparent for both public and private sector. However, Big Data quality can completely hinder the analysis of data (Alaoui & Gahi, 2019). For this, effective management of data is important but is not the sole important aspect. The EU has already taken steps in strengthening both investments and policies to support digitisation and research and innovation activities as well as adopted new regulations, eg. The Data Act, adopted by the Commission on 23 February 2022 (European Investment Bank, 2021). Policymakers and researchers should not only in the aspect of data quality and security but also consider the impact of data processing on fundamental rights and collective social and ethical values (Mantelero, 2018). The dialogue on ensuring optimal quality of data should be strengthened as well as actions to close the digital divide globally.

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