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THE APPLICABILITY OF GENERATIVE ADVERSARIAL NETWORKS IN THE MANAGEMENT OF CONTEMPORARY BUSINESS ORGANIZATIONS

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Abstract: Artificial intelligence solutions especially those based on neural networks and machine learning are now being applied in more and more areas supporting the management process of a modern business organization. A special role can be played by GAN (a generative adversarial network) that can support and optimize the decision-making process at all its stages and levels. The purpose of the paper is to present the possibilities of GAN networks applications, including an identification of the benefits of their potential implementation in contemporary business organizations. The research part was based on a qualitative approach, where the research sample included 30 respondents. Open-ended research questions were posed and they focused on the advantages and disadvantages of using GAN networks in the process of supporting the management of a business organization.

Key words: Artificial Intelligence, machine learning, deep learning, neural networks, business analytics, natural language processing, decision making support.

Introduction

The contemporary intelligent technologies such as business intelligence systems, narrow Artificial Intelligence solutions based on machine learning, deep learning and reinforcement learning, big data analytics, data mining techniques support managers in the process of a contemporary business organization management. Nowadays applicability of intelligent solutions embrace business organizations, companies, enterprises of all industry branches. One of the latest solutions embrace the domain of machine learning applied in many areas of business activity.

The aim of the paper is to answer three research questions:

1) What is the current state of GANs application in contemporary business organizations
2) What are the advantages resulting from GANs application in business organizations
3) What are the threats resulting from GANS application in business organizations

Characteristic of Generative Adversarial Networks

The notion of Generative Adversarial Networks was introduced by Ian Goodfellow et al. in 2014 year when the authors proposed "a new framework for estimating generative models via an adversarial process, in which two models are simultaneously trained: a generative model G that captures the data distribution, and a discriminative model D that estimates the probability that a sample came from the training data rather than G. The training procedure for G is to maximize the probability of D making a mistake" (Goodfellow et. al. 2014). The authors of GAN concept further state that when "G and D are defined by multilayer perceptrons, the entire system can be trained with backpropagation and in such a situation there is no need for any Markov chains or unrolled approximate inference networks during either training or generation of samples" (Goodfellow et. al. 2014). So, GANs may constitute an alternative to another solutions such as Boltzmann machine and Autoencoders. R. Agrawal breaks the GAN into 3 words it is: generative – how data is generated, adversarial – model training in an adversarial setting, networks – the application of deep neural networks for training. Jabbar and Omar state that "GAN is the most common learning model in both semi-supervised and unsupervised learning where

GAN takes a supervised learning approach to do unsupervised learning by generating fake or synthetic looking data" (Jabbar and Omar 2020). J. Feng et. al describing the basis of GAN functionality state that "in simple terms G wants to deceive D and maximize the probability that D makes a mistake by generating high-quality samples, and D wants to make the best possible distinction between real samples x and generated samples G(z). The optimization of GAN is realized by finding the Nash equilibrium between G and D. G and D are optimized by the value function V(D,G)" (Feng et. al. 2020).

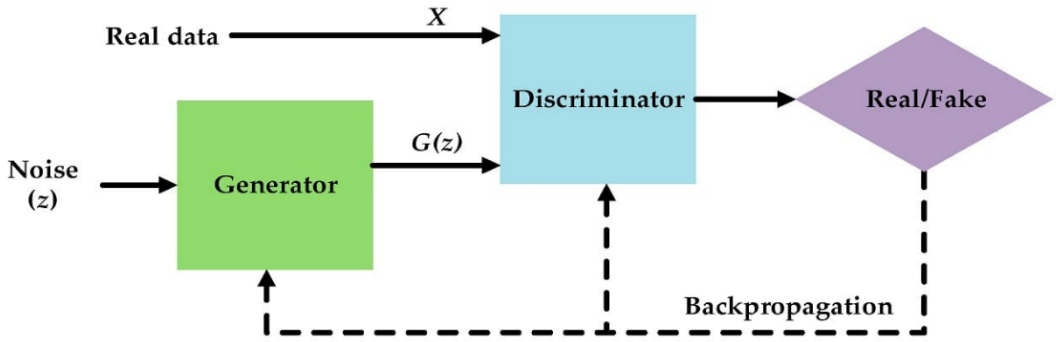

Fig. 1 The model of Generative Adversarial Network (GAN)

Source: J. Feng et. al. (2020) Generative Adversarial Networks Based on Collaborative Learning and Attention Mechanism for Hyperspectral Image Classification, https://www.mdpi.com/2072-4292/12/7/1149/htm

Cheng et al. on the basis of literature review evokes inspiration for GAN network functionality on the basis of zero-sum game theory "defined as a game in which two parties are strictly opposed to each other, where the gains of one party are bound to bring losses of the other party, and the gains and losses of both parties add up to zero" (Cheng et. al. 2020). Another comparison is presented by M. Tatariants who demonstrates the idea of GAN functionality referring it to e.g. writer and editor and who claims "GAN is like a writer and an editor, or an artist and a critic who always interact with each other, improving their skills, as well as generative and discriminative models during training" (Tatariants 2021).

N. Barla underlines the fundaments of Generative Adversarial Networks functionality stating that two networks should be trained independently. There can be distinguished the following GAN variants as Deep Convolutional GAN (DCGAN) using convolutional neural nets (CNNs) allowing for e.g. generation of higher quality images; Conditional GANs (CGAN) where some extra information is added and which are applied in e.g. image-to-image translation where e.g. Pix2Pix can be used in day-to-night or night-to-day images translation, low resolution to high resolution, sketch-to-drawing; CycleGAN using unpaired instead of paired image translation; text-to-image synthesis, such as StackedGAN; face inpainting known also as face completion; video generation (Barla 2023). Another types of GAN's include: fully connected GANs, Laplacian Pyramid of Adversarial Networks (LAPGAN), Generative Recurrent Adversarial Networks (GRAN), Adversarial Autoencoders (AAE), Information maximizing GANs (InfoGAN) and Bidirectional GAN (BiGAN).

There are many positive features resulting from GANs application but there can also be distinguished a few threats which are connected with the application of generated fake content like videos or images called deep fakes and which can be applied with a bad intention in different advertisement or political campaigns presenting untrue information.

As far as the future of GANs development is concerned it is worth mentioning Quantum Generative Adversarial Networks where Ngo, Nguyen and Thang conducted a survey concerning its recent advances seeking to augment machine learning in a quantum way. Such a solution called QuGan "may have a fully quantum or a hybrid quantum–classical architecture, which may need additional data processing in the quantum–classical interface. As quantum machines only work with data stored in

quantum states, classical data must be encoded into this form of data using e.g. basic, amplitude or angle encoding and what is more thanks to the superposition property of quantum computing, multiple inputs into a single quantum state can be encoded. ” (Ngo et. al. 2023).

Application areas and advantages of Generative Adversarial Networks implementation

There exist multiple applications of GAN networks in many areas form computer vision including image generation, translation (Zhengwei 2020), through drug discovery and various molecule development in pharmaceutical industry, diagnosis purpose imaging in the medicine or healthcare domain to GAN application in the support of contemporary business organizations management including support of decision making process. Alqahtani et. al conducted the review of GANs application in many different areas of which it is worth mentioning: generation of high quality images, upscaling which is generation of higher resolution image from lower resolution one; person re-identification allowing tracking the trajectory of a person (it is an example of security application); object detection (applied e.g. surveillance, image retrieval and driver assistance systems); video prediction and generation (predicting next frames in videos); facial attribute modification with face aging and rejuvenation (prediction of future looks); anime character generation; image to image and text to image translation; human pose estimation; de-occlusion which is removing the blocking of another object; image mixing; domain adaptation; sequential data based applications in speech and music domain; improving classification and recognition (Alqahtani 2019).

In the management of business organizations such solutions are applied in design and management of business processes where e.g. Ch. Van Dun et al. propose the approach called ProcessGAN to combine business process improvement (BPI) and computational creativity (Christopher van Dun et. al. 2023). The GAN networks can be integrated into business models of contemporary business organizations. A. Gonfalonieri states that besides its most common application related to image and/or content generation e.g. text to image and image to image translation “they can be used to re-formulate and solve several existing and machine learning problems in new ways” (Gonfalonieri 2020) and mentions “utilization of synthetic images produced by GAN for data augmentation purpose in projects”. The GAN having tremendous impact on creativity can support designing future products and can be combined with another machine learning based solutions such as sentiment analysis tools in order to explore new trends and allowing to notice “how consumers respond to new products” and what is more “GAN generated content will become difficult to distinguish from real content” (Gonfalonieri 2020).

Another worth mentioning application of GAN networks is the marketing area where they can improve products descriptions. One of such an example is presented by R. Martinez and J. Kamalu where the authors analyzed “how GAN models can replicate text patterns from successful product listings on Airbnb – apartment rental platform”. Such solutions can “increase the accuracy of product recommendations on websites” (Martinez Kamalu 2018).

In case of fashion industry so called Pose Guided Generation Network (which can be trained on the e.g. DeepFashion dataset) can be applied to present “person images in arbitrary poses based on an image of that person and a novel pose” (L. Ma et. al 2017). GAN gives the possibility to “automatically generate images for a given product” as well as logos and with connection to AI assistants can lead to “reach a target audience” (L. Ma et. al 2017). In advertisement there exist possibility to create videos, images, audio files to compare fictitious content with a real one or create a multi-layer images.

The anomaly detection finds its application in detecting fraudulent transactions where GANs are able to generate new data (Sabuhi et.al. 2021). In the finance domain GANs can be applied in “making accurate forecasts on the closing price of stocks” and these research results conducted by Staffini confirm that “financial time series forecasting may benefit from employing GANs”. Those networks can also find weaknesses of another IT systems (Staffini 2022).

The table 1 presents the selected areas of GAN application in contemporary business organizations focusing mainly on the marketing and promotion areas, business processes improvement and automation.

Table 1. Areas of GAN applications in the management of business organizations

Business application area of GAN	Detailed application of GAN
Marketing and promotion area	Content and images generation, pose generation e.g. in a fashion industry, customer behaviour simulation
Business processes management e.g. in the area of production, logistics	Improvement, optimization and automation of processes, simulation of different scenarios,
Advertisement domain	Generation of a realistic video and audio content
E-commerce	Images of product or services offers generation
Entertainment domain	Augmented and virtual reality, chatbots
Architecture and 3D designing	Offices and houses decor
IT systems security	Anomaly detection, data privacy ensurance

Source: Authors' study based on conducted research and literature review

The GANs interconnected with another intelligent solutions such as big data analytics, BI on premise and cloud analytics systems, data mining tools, AI and machine learning tools based on supervised, semi-supervised and unsupervised learning have significant impact on the acceleration, increase of efficiency and efficacy of decision making process (Sobczak, Ziora 2023). The application of Robotic Process Automation (RPA) allows for automation of many tasks (Sobczak, Ziora 2021). Large language models and other solutions of Natural Language Processing such as sentiment analysis together with previously mentioned technologies constitute a holistic view on the management process of contemporary business organizations (Ziora 2022a). What is more deep learning and reinforcement learning solutions improve decision making process at all its stages and levels (Ziora 2022b).

Research methodology

The qualitative study was conducted in November 2022 on a group of 30 respondents (n=30), who were second-cycle students of Management and Finance and Accounting (Faculty of Management, Czestochowa University of Technology, Poland), most of whom work in companies that have implemented intelligent technological solutions based on machine learning – (90% of respondents). The 10% of respondents declared that intelligent technologies supporting the management process of a given company will be implemented soon. In open-ended questions, respondents were asked to indicate the advantages and disadvantages of using GANs in the management of a modern business organization, additionally indicating branches of its implementation. The research limitations may be connected with the size of research sample and the fact that not all respondents work in companies that have implemented machine learning.

Presentation of research results

The results of the survey indicated such advantages of GANs application as (figure 2):

- The possibility of content creation for advertisement purposes 80% of respondent,
- The possibility to improve and automate business and decision processes 70%,
- Products and services images creation for e-commerce purpose 60%,
- Anomaly detection in the IT security domain.
- Scalability of a solution 30%
- Finding weaknesses in the functionality of other systems 10%

It is worth noting that the answers are consistent with the benefits indicated by other authors and presented in the literature of subject review.

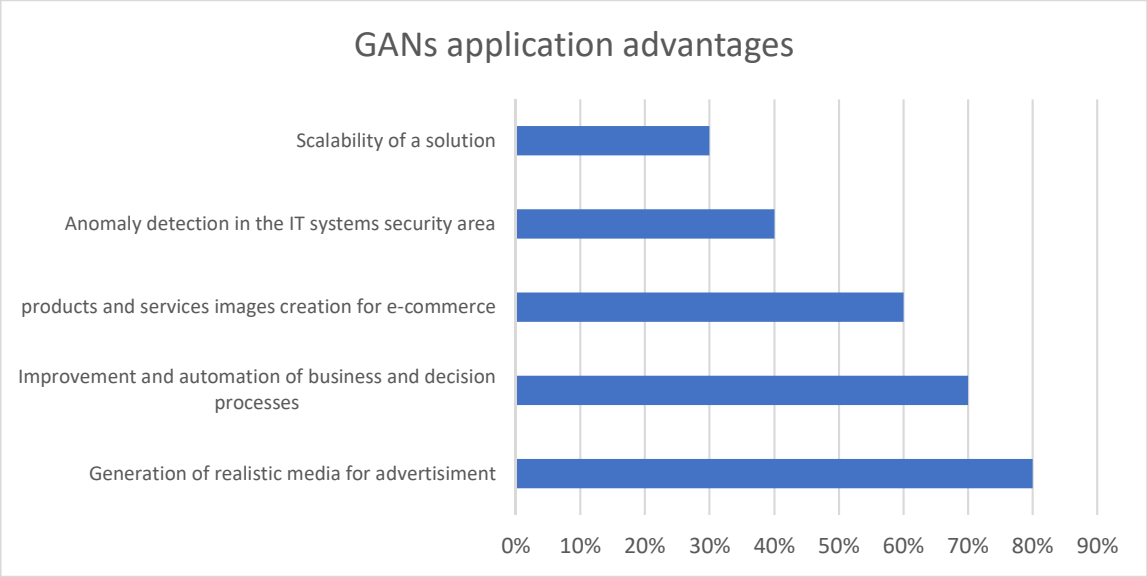

Figure 2. GANs application advantages within selected industries

Source: Authors' study based on conducted research

The main disadvantages of using GANs according to respondents' answers are connected with the possibility of deep fake generation having negative impact on business activity/reputation. Another disadvantages are connected with ensuring appropriate safety of this solution.

Conclusion and future research recommendations

The latest solution in the area of artificial intelligence and especially machine learning such as GANs can play a significant role in many areas of managing a modern business organization improving many areas and industry branches. The future of the development of such solutions is related to the further increase in the power of computing units, the use of modern hardware solutions such as hardware simulation of neural networks using neuromorphic systems. Another promising direction of development are quantum GANs. The paper outlined the current state, benefits and threats resulting from GANs application in various branches of contemporary business organizations. It can be concluded that this promising intelligent technology implemented in multiple areas has many advantages which prevail over its disadvantages.

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