ARTIFICIAL INTELLIGENCE AND VOICE MODELING: CUTTING-EDGE TECHNOLOGY IN MUSIC PRODUCTION

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SUMMARY. This article reports on some of the benefits that Artificial Intelligence has brought during the renaissance of AI science. It also reveals a few of the shortcomings surrounding it from 2010 until the beginning of 2025. The examples provided reflect our approaches regarding AI, motivating us to present them here briefly. The article reinforces that responsible development and integration of Artificial Intelligence in music is a priority.

Keywords: Artificial Intelligence, Text-to-Speech, AI Voice, AI Singing

A Motivated Introduction

Asked by University Professor Ph. D. Habil. Mirela Mercean-Țârc, during an interview[2] in 2022, what will be "the future of new technologies in artistic creation?", I said then in a few words that "the answer is inevitable: Artificial Intelligence". Without any doubt, it was not a prophecy but, rightly, the acceptance of a possible and not-distant future in which AI will be present in the lives of musicians and will stir their feelings.

Interestingly, in December of the same year, significant progress was noted in Narrow Artificial Intelligence, a type of AI excelling in performing precise tasks, accelerating its popularity.

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[2] Mercean-Țârc, Mirela. *„Aici și acum"* un spectacol *New Media Art* – Interviu cu compozitorul Adrian Borza" *("Here and Now" A New Media Spectacle – Interview with composer Adrian Borza).* In *Colloquia Artium*, 2, 2022, pp. 34 (20–35).

The OpenAI[3] company, backed by Microsoft, was offering the general public for free a sophisticated means of written conversation, generically called a chatbot, namely ChatGPT (abv. for Chat Generative Pretrained Transformer), which would attract immense attention: over 1 million users opened online accounts in just 5 days[4], and the same web application recorded an impressive 100 million unique visitors only 2 months after its launch[5].

In early 2023, Narrow AI became mainstream after more than 70 years of research in computer science, psychology, and cognitive science. ChatGPT was viewed with exuberance and, at the same time, with justified concern: back to school, "teenagers were already asking the chatbot – released in late 2022 – to compose essays and answer take-home tests."[6]

However, the "brilliant and weird" ChatGPT was not a sensational news story for the public familiar with Artificial Intelligence. Years ago, more precisely in September 2016, spoken voice synthesis based on generative AI, known as WaveNet[7], was sensational. This high-end technology has been implemented in the Google Cloud Text-to-Speech[8] service and Google Android operating system for smartphones.

We used this technology to create the promotional video for the 2018 edition of the "Elektro Arts" Digital Arts Festival[9].

The WaveNet model was described as being "a deep neural network for generating raw audio waveforms. The model is fully probabilistic and autoregressive, with the predictive distribution for each audio sample conditioned on all previous ones; nonetheless we show that it can be efficiently trained on

[3] OpenAI OpCo, LLC is a private Artificial Intelligence research and implementation company. https://openai.com/ (21.12.2024).

[4] Roose Kevin. "The Brilliance and Weirdness of ChatGPT". In *The New York Times*, Dec. 5, 2022. https://web.archive.org/web/20230118134332/https://www.nytimes.com/2022/12/05/technology/chatgpt-ai-twitter.html (21.12.2024).

[5] Milmo Dan. "ChatGPT reaches 100 million users two months after launch". In *The Guardian*, Feb. 2, 2023.
https://www.theguardian.com/technology/2023/feb/02/chatgpt-100-million-users-open-ai-fastest-growing-app (21.12.2024).

[6] Associated Press. "2023 was the year AI went mainstream. It was also the year we started to panic about it". In *Euronews*, Dec. 27, 2023.
https://www.euronews.com/next/2023/12/27/2023-was-the-year-ai-went-mainstream-it-was-also-the-year-we-started-to-panic-about-it (21.12.2024).

[7] Google DeepMind is a private research laboratory with an interdisciplinary approach to building general AI systems. https://deepmind.google/ (21.12.2024).

[8] Google Cloud Text-to-Speech is a service created to transform text into artificial speech using AI technologies from the private company Google, renamed Alphabet in 2015. https://cloud.google.com/text-to-speech (21.12.2024).

[9] The official social media page of the "Elektro Arts" Digital Arts Festival. *Promotional video*. https://www.facebook.com/elektroarts/videos/elektro-arts-2018/1513863638735815 (21.12.2024).

data with tens of thousands of samples per second of audio. When applied to text-to-speech, it yields state-of-the-art performance, with human listeners rating it as significantly more natural sounding than the best parametric and concatenative systems for both English and Mandarin. A single WaveNet can capture the characteristics of many different speakers with equal fidelity and can switch between them by conditioning on the speaker's identity. When trained to model music, we find that it generates novel and often highly realistic musical fragments."[10]

The Impact of Artificial Intelligence

The dawn of Artificial Intelligence was observed towards the end of 1950 (year) when mathematician Alan Turing[11] proposed the problem of The Imitation Game[12] (or Turing Test) and launched a provocative question: "Can machines think?"

On the other hand, Professor Emeritus John McCarthy[13] has been credited[14] by Stanford University in the U.S. with the invention of "Artificial Intelligence" syntagma. Professor McCarthy's 1955 definition was as follows: "it is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."[15]

After a period of anonymity for the general public, AI science entered a renaissance in the 2010s decade.

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[10] Oord, Aaron van den & Co. (Sander Dieleman, Heiga Zen, Karen Simonyan, Oriol Vinyals, Alex Graves, Nal Kalchbrenner, Andrew Senior, Koray Kavukcuoglu). "WaveNet: A Generative Model for Raw Audio". In *ArXiv: Computer Science > Sound*, Cornell University, Sep. 2016, pp. 1 (1–15). https://arxiv.org/abs/1609.03499v2 (21.12.2024).

[11] Alan Turing (1912–1954) was a British mathematician and logician. He brought "major contributions to mathematics, cryptanalysis, logic, philosophy, and mathematical biology and also to the new areas later named computer science, cognitive science, artificial intelligence, and artificial life." https://www.britannica.com/biography/Alan-Turing (21.12.2024).

[12] Turing, Alan M. "Computing Machinery and Intelligence". In *Mind*, New Series, Vol. 59, No. 236, Oct. 1950, Oxford University Press on behalf of the Mind Association, pp. 443 (443–460).

[13] John McCarthy (1927–2011), an American mathematician and computer scientist, "was a pioneer in the field of artificial intelligence (AI); his main research in the field involved the formalization of commonsense knowledge."
https://www.britannica.com/biography/John-McCarthy (21.12.2024).

[14] Manning, Christopher. *Artificial Intelligence Definitions*, Stanford University, HAI Human-Centered Artificial Intelligence, Sep. 2020.
https://hai.stanford.edu/sites/default/files/2020-09/AI-Definitions-HAI.pdf (21.12.2024).

[15] McCarthy, John. *What is Artificial Intelligence?*, Computer Science Department, Stanford University, 2007, pp. 2 (1–15). http://jmc.stanford.edu/articles/whatisai/whatisai.pdf (21.12.2024).

In medical sciences, for example, disease diagnosis, intensive care medicine, and the pharmaceutical industry, the advance of AI has been possible "thanks to the widespread health data digitalization, which made it possible to create big data systems capable of providing a solid basis for intelligent algorithms."[16]

The privately funded commercial sector has brought a fulminating expansion of AI technology during companies' fights to gain market shares. Information Technology (IT) corporations have continued to convince their consumers of the benefit of virtual assistants created for conversation. They implemented concatenative or, as the case may be, neural speech synthesis, in Apple Siri (2010), Amazon Alexa (2013), Microsoft Cortana (2014–2021), Google Assistant (2016), Google Gemini (2023), and so on.

Likewise, the projects Apple Project Titan (2014–2024) and Google Waymo One (2010), associated with the automotive industry, seemed to be trying to transform the illusion of science fiction film productions into reality, in fact producing prototypes of fully automated vehicles that drive themselves without human intervention.

Other large industries, such as transportation, commerce, and marketing have further expanded the already massive impact of digital technology on people's lives in almost every aspect through car navigation digital applications known as Global Positioning Systems (GPS) and intelligent algorithms used in social media applications, mainly WhatsApp and Facebook, the latter luring consumers with persuasive advertisements.

In this regard, additional examples are the global consumer markets, smart lighting, smart home appliances controlled by mobile phones, and, last but not least, smart TVs. All smart by definition, equipped with sensors (light, proximity, etc.), miniature optical and audio devices, and Text-to-Speech technology have flooded a futuristic quotidian life, while some manufacturers competed in claiming that their products use Artificial Intelligence.

The Sophia Robot and AIVA Software

The innovations in Artificial General Intelligence and Generative Artificial Intelligence, Sophia and AIVA remain spectacular for some people and controversial for others.

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[16] Bellini, Valentina & Co. (Marco Cascella, Franco Cutugno, Michele Russo, Roberto Lanza, Christian Compagnone, Elena Bignami). "Understanding basic principles of artificial intelligence: a practical guide for intensivists". In *Acta Biomed*, Vol. 93, No. 5: e2022297, 2022, pp. 2 (1–15).

Sophia, a humanoid robot developed by Hanson Robotics[17], which was granted citizenship in the Kingdom of Saudi Arabia 1 year after its activation in 2016, was the outcome of a combination of state-of-the-art technologies, through which the robot was able to interact and communicate with humans[18]. Among them, we mention Computer Vision (recognition and interpretation of facial and gestural expression input), Natural Language Processing (understanding and generating human-like speech), Machine Learning (automatic learning algorithms), and Robotics (physical control of movements).

The AIVA (abv. for Artificial Intelligence Virtual Artist) model of Aiva Technologies[19], a company specializing in the application of generative AI in film and game music composition, was considered by the press to have gained the status of composer member of SACEM (Société des Auteurs, Compositeurs et Éditeurs de Musique) in France and Luxembourg, in 2017[20].

It was a speculation. It can be noted that there are 1908, and the number is growing, of musical works registered[21] with SACEM under the pseudonym AIVA. The SACEM statute stipulates that to be protected at the national and international levels, candidate composers must declare their nationality and prove their identity with a (legal) document[22].

A first conclusion. It is easy to understand that Artificial Intelligence has progressed rapidly and significantly in the last 15 years, and its influence on human society has never been more pronounced than today. AI brings possible advantages, but it also introduces potential risks. These reflect nothing more than the tip of the iceberg.

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[17] Hanson Robotics, Limited is a privately held AI and robotics technology company in Hong Kong, dedicated to creating socially intelligent machines. https://www.hansonrobotics.com/ (21.12.2024).

[18] Brad, Stelian. *Technologies Behind Sophia Humanoid Robot*, Technical University of Cluj-Napoca, Robotics, Feb. 12, 2023.https://utcn-robotica.ro/technologies-behind-sophia-humanoid-robot/ (21.12.2024).

[19] Aiva Technologies SARL is a private Luxembourg company, established in 2016. https://www.aiva.ai/ (21.12.2024)

[20] Lauder, Ed. "Aiva is the first AI to Officially be Recognised as a Composer". In *AI Business*, Mar. 10, 2017. https://aibusiness.com/verticals/aiva-is-the-first-ai-to-officially-be-recognised-as-a-composer (21.12.2024)

[21] SACEM. *The SACEM Repertoire*. https://repertoire.sacem.fr/en/results?filters=parties&query=AIVA#searchBtn (21.12.2024).

[22] SACEM. "Special Conditions of Admission". In *Statutes 2024 and General Regulations 2024*, Art. 8, pp. 25 (1–68). https://societe.sacem.fr/docs/Statuts_UK_2024.pdf (21.12.2024).

The AI Index 2024 Report

A worthy of consideration perspective on the influence of Artificial Intelligence in research, science, economics, education, legislation, and its public perception is offered by Stanford University.

The Stanford Institute for Human-Centered Artificial Intelligence (HAI) systematically produces The AI Index Report, "recognized globally as one of the most credible and authoritative sources for data and insights on artificial intelligence."[23] The 2024 Report provides 502 pages of "unbiased, rigorously vetted, broadly sourced data". We quote 10 conclusions[24] for our readers:

1. *AI beats humans on some tasks, but not on all.*
2. *Industry continues to dominate frontier AI research.*
3. *Frontier models get way more expensive.*
4. *The United States leads China, the EU, and the U.K. as the leading source of top AI models.*
5. *Robust and standardized evaluations for LLM responsibility are seriously lacking.*
6. *Generative AI investment skyrockets.*
7. *The data is in: AI makes workers more productive and leads to higher quality work.*
8. *Scientific progress accelerates even further, thanks to AI.*
9. *The number of AI regulations in the United States sharply increases*
10. *People across the globe are more cognizant of AI's potential impact—and more nervous.*

Responsible Development of LLM(s) — A Real Concern

One of the problems created by the development of AI and which has taken almost the entire society by surprise is the legislative one: the lack of clarity regarding intellectual property rights, identified at the end of 2024.

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[23] Maslej, Nestor & Co. (Loredana Fattorini, Raymond Perrault, Vanessa Parli, Anka Reuel, Erik Brynjolfsson, John Etchemendy, Katrina Ligett, Terah Lyons, James Manyika, Juan Carlos Niebles, Yoav Shoham, Russell Wald, and Jack Clark). *The AI Index 2024 Report*, AI Index Steering Committee, Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2024, pp. 2 (1–502). https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf (21.12.2024)

[24] *Ibidem*, pp. 5–6.

Widely discussed is the implementation of LLM(s) and ML, also the potential to plagiarize protected materials[25].

Before developing this topic, we believe that some terminological clarifications are necessary:

- LLM(s), Large Language Model(s), "are deep learning algorithms that can recognize, summarize, translate, predict, and generate content using very large datasets."[26]
- ML, Machine Learning, is an algorithm that is "more dependent on human intervention to learn".[27]
- Deep Learning is a type of ML that uses artificial neural networks for learning. "The deep learning process can ingest unstructured data in its raw form (e.g., text or images), and it can automatically determine the set of features which distinguish different categories of data from one another. This eliminates some of the human intervention required and enables the use of large amounts of data."[28]

Returning to the main issue, some studies have shown that large-scale linguistic models:

1. Can extract not only ideas and facts from texts but can also memorize word for word (verbatim) large fragments of texts under the protection of the law, during training. Therefore, the redistribution of such texts raises ethical and legal issues in terms of copyright[29];

2. Due to their superior performance, they can produce very similar content to the original. Thus, if the original is protected, some models may infringe intellectual property rights[30].

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[25] Liu, Xiaoze & Co. (Ting Sun, Tianyang Xu, Feijie Wu, Cunxiang Wang, Xiaoqian Wang, Jing Gao). "SHIELD: Evaluation and Defense Strategies for Copyright Compliance in LLM Text Generation", Purdue University – United States, Westlake University – China, pp. 2 (1–31). In *ArXiv: Computer Science > Computation and Language*, Cornell University, Jun. 18, 2024. https://arxiv.org/pdf/2406.12975v1 (21.12.2024).

[26] NVIDIA Inc. *Large Language Models Explained*.
https://www.nvidia.com/en-us/glossary/large-language-models/ (21.12.2024).

[27] IMB Inc. *What is machine learning?* https://www.ibm.com/think/topics/machine-learning (21.12.2024).

[28] *Ibidem*.

[29] Karamolegkou, Antonia & Co. (Jiaang Li, Li Zhou, Anders Søgaard). "Copyright Violations and Large Language Models". In *ArXiv: Computer Science > Computation and Language*, Cornell University, 20.10.2023, pp. 1 (1–10). https://arxiv.org/pdf/2310.13771 (21.12.2024).

[30] Zhao, Weijie & Co. (Huajie Shao, Zhaozhuo Xu, SuzhenDuan, and Denghui Zhang). "Measuring Copyright Risks of Large Language Model via Partial Information Probing". In *Proceedings of the 21st International Conference on Distributed Computing and Artificial Intelligence* (DCAI24), New York, Oct. 21–25, 2024, pp. 2 (1–8).
https://arxiv.org/pdf/2409.13831v1 (21.12.2024).

On the legality and professional ethics debate front, the regulation of AI is at an early stage. The European Union introduced, in June 2024, a new legislation on AI, "Artificial Intelligence Act, Regulation (EU) 2024/1689", which will continue to be applied in stages in the member states.

Article 53, Obligations for Providers of General-Purpose AI Models[31], would enter into force on August 2, 2025. The AI supplier needs to conform with point 1, letters (c) and (d) as follows:

(c) put in place a policy to comply with Union law on copyright and related rights, and in particular to identify and comply with, including through state-of-the-art technologies, a reservation of rights expressed pursuant to Article 4(3) of Directive (EU) 2019/790;

(d) draw up and make publicly available a sufficiently detailed summary about the content used for training of the general-purpose AI model, according to a template provided by the AI Office.[32]

Accountable AI Music — Another Real Problem

As expected in the absence of clear regulations, music generated with AI technology has aggressively invaded, through competitive sites[33], not only the consumer market of entertainment music but also the marketplace managed by enthusiastic producers of audio and audiovisual content for various streaming platforms[34].

As a result, the balance between genuine art and artificial creation has deteriorated, despite the latter's undisputed superior qualities.

Nicolas Dauban, DSP (Digital Signal Processing) engineer at IRCAM Amplify, a commercial branch of the prestigious "Institut de recherches et coordination acoustique/musique" in Paris, stated that "the models of music generation achieved by AI have progressed to such a level that **it will soon be impossible to discern them from real artists**, using only our ears."[35]

IRCAM Amplify has become, through its role as a catalyst for industry and research, a fearsome actor in identifying musical productions raised from Artificial Intelligence.

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[31] European Union. "Artificial Intelligence Act, Regulation (EU) 2024/1689". In *Official Journal*, Jun. 13, 2024. https://artificialintelligenceact.eu/article/53/ (21.12.2024).

[32] *Ibidem*.

[33] Aimi, Inc. https://www.aimi.fm/; Skywork AI PTE. LTD. https://www.melodio.ai/; Delaware Mubert, Inc. https://mubert.com/; Kunlun Tech Mureka https://www.mureka.ai/; Musixy. https://musixy.ai/, Supermusic. https://supermusic.ai/, etc. (21.12.2024).

[34] SoundCloud. https://soundcloud.com/a-i-music; Google YouTube https://www.youtube.com/@ai_music_official etc. (21.12.2024).

[35] Dauban, Nicolas. *Our AI-Generated Music Identification journey*, IRCAM Amplify, 22 May 2024. https://www.ircamamplify.io/blog/ai-generated-music-identification-journey (21.12.2024).

Second interim conclusion. We consider that a proper, responsible use of Artificial Intelligence must be considered by the policymakers, the AI technology providers, and the end-users. However, in these troubled times, one can stray from ethical conduct.

Artificial Intelligence and Singing Voice

As for us, we use Artificial Intelligence with the aim of studying up-to-date AI singing voice generators and, above all, without abusing it.

For informational purposes, we will briefly present a selection of the features of a generative AI voice synthesis software, while leaving the artistic implications of the model in music production to the readers' discretion.

Licensed to use intellectual property, the AI model was trained on the voices of professional pop-rock vocalists. It is able to generate sounds with text in English and Spanish, for example.

The common feature with the Virtual Studio Technology Instrument (VSTi) is that it reacts to MIDI messages, via a keyboard or through a piano roll-type graphical interface. Thus, the music that will potentially be created will be attributed to the composer or producer, by right.

A notable difference between the vocal model and virtual instruments lies in creatively and intuitively controlling the modeling parameters. The representation of physical and synthesis properties of sound is replaced with a package of perceptual descriptors, which immediately attract attention, such as *Soft, Soulful, Steady, Bold, Warm, Delicate, Tender, Lucid, Firm, Powerful,* and *Resonant*.

As an illustration in a *sui generis* demo vocal performance of the one-line poem *După tsunami*[36], a miniature lasting only 22 seconds, we have used the following descriptors: *Bold* for soprano I and alto voices, *Powerful* for soprano II, and *Steady* for male baritone voice.

The poem, *A Ship in Drift through the Disappeared Harbor*[37], was transferred to the model in a way similar to editing scores containing poetic text, and then automatically converted into phonetic symbols, thus preparing for the synthesis of the artificial voice. The phonetic transformation was grounded on the standard called ARPAbet[38], "a phonetic alphabet designed for American

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[36] *După tsunami* is part of our vocal suite *Fuioare de fum – Poeme mignone pentru cvartet vocal)*, composed in 2023.

[37] Letiția Lucia Iubu. *Inscripții pe un bob de grâu* volume, MJM Edition, Craiova, 2018, pp. 69 (1–112). The poem *După tsunami* has a single line: *O navă în derivă prin portul dispărut*. The English translation belongs to the poem's author.

[38] Developed by the Advanced Research Projects Agency (ARPA).

English that uses ASCII[39] symbols; it can be thought of as a convenient ASCII representation of an American - English subset of the IPA."[40] [41]

From a computational perspective, the phonetic transcription looks like this:

Table 1

English	*A ship in drift through the disappeared harbor*
ARPAbet	ax / sh ih p / ih n / dr ih f t / th r uw / dh ax / d ih s ax p ih r d / hh aa r b er

Phonetic transcription with ASCII characters

Voice Processing in Music Production

In the current music production process, the stages of audio mixing and mastering are indispensable. In this sense, the 4 voices produced by the generative AI model were processed, as they were generated in real-time, using a Digital Audio Workstation (DAW) software, including specialized software components VST plugins.

According to the practice, we considered the processing of the audio signal in terms of sound strength (gain, volume, compression, maximizer), spatial localization (panning, reverberation), and, last but not least, harmonic distortion (transient, saturation). The plugins used are in fact digital emulations of physical analog equipment.

The musical result of this endeavor[42] of generating and processing singing voice with text in English through a cutting-edge AI synthesis model, can be found on the author's channel on the social media and YouTube streaming platform.

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[39] American Standard Code for Information Interchange.
[40] Jurafsky, Daniel & Martin, James H. *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models*, Third Edition draft, Stanford University, 2024, pp. 2 (1–29).
[41] International Phonetic Alphabet.
[42] Borza, Adrian. *AI Voices*, YouTube channel. https://youtu.be/LegOnHdfs6Q (10.1.2025).

Highlighting Conclusions

Some of our readers probably raised their eyebrows in amazement when we assigned vocal clones from the consumer music industry to the soprano I and II, alto, and baritone voices of our score.

The intention is to draw attention to the fact that at the beginning of 2025, the pecuniary interest of suppliers of artificial vocal models remains targeted toward producers of entertainment music since this popular genre with its myriad ramifications is accessible to its extremely tremendous audience.

We conclude by reiterating that the ®evolution of Artificial Intelligence is on a path of no return, which entails advantages, as well as risks. Best practices in the development and integration of AI technology in music and other fields are dependent on the authority of the lawmaker, the responsibility of the provider, and the ethics of the beneficiary.

Are we prepared for the AI Revolution?

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