Res Intell Manuf Assem, 2022, 1(1): 28-34
DOI: 10.25082/RIMA.2022.01.004

COMMENTARY

Creating humanoid intelligent digital twin on spectral and holographic approaches

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Received: October 30, 2022;
Accepted: December 2, 2022;
Published: December 6, 2022.

Citation: Bryndin E. Creating humanoid intelligent digital twin on spectral and holographic approaches. *Res Intell Manuf Assem*, 2022, **1**(1): 28-34. https://doi.org/10.25082/RIMA.2022.01.004

Abstract: A person perceives his environment through the influence of various complexes of conjugated vibrations on the eyes, ears and other sensitive components of the body. The psyche and neural systems of a person form the impression of vibration impact. The mind creates a language equivalent and connects it with the impression that has formed. Communication links are formed between impressions and language equivalents. Live vibrational information involves a person in a communicative creative process. In the creative communicative process, human intelligence develops. The combination of modern interdisciplinary technologies can contribute to the creation of an intelligent digital twin, similar to humans on spectral and holographic principles, relying on achievements in the field of artificial intelligence. The digital twin fixes the effects of the environment in the form of a spectrogram, and stores the effect result in the form of a hologram. Multilayer neural network systems with additional training work with spectra and holograms and their communications. Language communications are associated with spectra, holograms and their communications. A humanoid digital twin with an ensemble of intellectual agents will be able to form and develop intelligence in interaction with similar digital twins and people.

Keywords: spectrogram, hologram, multilayer neural networks, ensembles of intellectual agents, intellectual digital twin

1 Introduction

Digital twins have become a very useful tool for industrial companies. And the statistics confirm that. From 2021, half of all large industrial companies, according to statistics from the consulting company Gartner, use digital twins. Deloitte predicts the global digital twin market will reach $16 billion by 2023.

Digital twins can significantly enhance the ability of enterprises to make active decisions on the database, increase the efficiency of their activities and eliminate potential problems. They can also provide an opportunity to safely and economically work through scenarios and experiment with the future, says the Deloitte report.

Experts predict that it will be possible to use a digital twin in everyday life. For example, the owner of a car will be able to simply point a mobile phone at the car and get data on the oil level in the engine, information about the operation of the car systems or about the timing of the next maintenance.

The digital twin will become closer to the person. Experts say that digital twins are able to improve quality and prolong human life. Today, Russian scientists are already working on creating a digital copy of a person. Such a twin will be able to control the physical condition of the patient, predict diseases and prevent the risks of their development, will make treatment for each person individual. In the future, the use of such virtual models of the human body or organs will allow doctors to track patient health data online.

Digital twin technology also finds application in urban environments. Today, many cities acquire their digital counterparts. Among the first were Singapore, French Rennes and Indian Jaipur. A virtual copy of all physical objects of the city allows you to manage it remotely, as well as solve city problems. For example, in Singapore, the main task that is solved using digital twins is water management. For this, all water supply systems, water quantity control, meters, and so on were digitized.

The digital twin of the city is such a complex complex system that is implemented in stages. First, an urban problem is fixed, which cannot be solved in traditional ways. The first stage begins to form an intellectual double with an ensemble of intellectual agents. The double begins to collect information about the object, accumulate this information. Further, the digital twin is added intelligence by an ensemble of digital agents, various services are added so that on its basis it is already possible to solve the urban problem.

In solving the problems of the urban environment, intelligent digital twins will use digital holography and spectroscopy. Using digital holography, you can create real three-dimensional visualization of objects and scenes. On this principle, 3D displays are now being actively developed that allow you to visualize high-quality images. The holographic image of the part is divided by sections into projections and then, under program control, fast layer-by-layer printing of each projection is carried out.

One of the current achievements is the connection in 5G using holographic principles to create the image of the interlocutor. The directions of digital holography applicable in scientific and applied research are actively developing: holographic microscopy (visualization of micro- and nano-objects) and holographic interferometry (dynamic registration of changes in the parameters of the object - temperature, shape, refractive index).

In addition, digital holography is already widely used in medical and biological imaging, in data coding, transmission and storage systems, and also allows to increase the security of products, banknotes and bank cards.

Digital Holograms can simulate three-dimensional space. In May 2017, scientists from the University of Technology Munich developed a method for producing three-dimensional holograms using a Wi-Fi router. The method of scientists from the University of Technology Munich allows you to create copies of the premises, displaying objects around them. The technology can be used to locate and rescue victims under an avalanche or collapsed buildings.

In February 2017, Barbie unveiled a holographic bot doll that responds to voice commands. Researcher Daniel Smalley of MIT Media Lab proposed a technology for holographic television based on the use of an optical chip. In the field of holographic telepresence, “PORTL” made a single lightbox for teleportation. This complex is designed so that one person can communicate remotely with other people with the maximum effect of presence and feedback. When teleporting live, the user gets the opportunity to see and hear the audience on the other end of the Internet connection.

In April 2017, the two largest operators Verizon (USA) and Korea Telecom (South Korea) made the first international holographic call using 5G technology. When calling, holograms of the interlocutor are formed, which completely convey the emotions and gestures of the user. During the test, the hologram of the interlocutor was reflected on the screen of the holographic device. Holographic communication technology requires high bandwidth, so it is only possible in 5G networks, which are 10-100 times faster than existing networks. This technology allows the mass production of cars equipped with a holographic display to be launched.

Hololens allows you to visually combine a real building object and its digital holographic model. Combined holography helps to quickly detect collisions, advance or lag behind the plan. Mixed reality helps visualize the future interior in real space and quickly make a decision, as well as perform various operations with holographic guidance and instructions tied to specific equipment and simultaneously monitor the actions of employees on the ground from the operations center.

For museums, software is being developed that allows remote holographic excursions. Recent advances in artistic holography involve the creation of optoclones - ultra-realistic full-color holograms. The images of objects they recreate are almost indistinguishable from the originals themselves. This technology was developed on the basis of comprehensive research, including new photo-recording environments, new optical arrangements of laser RGB systems and special LED devices with a controlled spectrum.

In a published article in the journal Optics Communications, a recognition method was proposed simultaneously by shape and spectral characteristics, applicable, for example, in orientation devices in space or for identifying biological species. The elements of holographic memory being created now are becoming one of the most important components of artificial intelligence.

Currently, digital holography is gradually developing and widely implemented [1–15]. They learned to obtain spectrograms by rotating the hologram relative to the incident radiation by a certain angle. Vibration communication of spectrograms with holograms, combined holography, neural network multilayer systems with additional training by ensembles of intelligent agents and holographic memory allow us to start creating a humanoid intelligent digital twin on spectral and holographic approaches [16].

2 Intelligent digital twins with spectral holographic properties

Intelligent digital twins with spectral holographic properties contain neural network multilayer systems with additional training, ensembles of intelligent agents and holographic memory.

2.1 Neural network multilayer systems with additional training

Stanford University neurophysiologist Carl Pribram views the brain as a hologram [17]. Memory, as one of the central functions of the brain, has a distributed character, and each part of the brain contains the whole.

Each biological structure, starting from the cell level, is the source of a wide range of fields. All vibrations or vibrations of internal organs are coherent. It is coherent radiation that creates the holographic image. In a biological organism, coherent fields form a dynamic spatiotemporal interference structure-hologram. The radiation of each organ is considered as a reference relative to all other organs.

The holographic model of the psyche explains the fact of instant recognition. The wave principle of holography allows you to imagine a mechanism that can almost instantly extract from storage the information that is encoded using such a wave process. Any place in the brain can trigger information waves, for this it is enough to reproduce in this place a pattern of activity similar to what occurs in it when the corresponding wave passes. The wave function can be analyzed using the Fourier transform. There are similarities between storing information in holographic memory and in a hologram, which can also be analyzed using a Fourier transform. Holographic memory establishes associative links between different parts of non-uniformly stored information. The hologram contains everything that is in the multiple updating system from the end-changing professions. The hologram reflects the life of a person and becomes the basis for vocational training of a multi-layer holographic neural network.

Multilayer holographic neural network architecture has an array of neurons m x n where m is the number of Fourier decomposition descriptors and n is the dimension of the input vector. Weights in the first layer have the physical meaning of the frequencies with the highest energy, and weights in the second layer have the meaning of Fourier series coefficients. Thus, the number of inputs at each neuron of the output layer is m $\times$ n, which corresponds to the number of Fourier series coefficients. Creating an array of neurons requires the use of large computational resources.

In recognition tasks at the output, neural networks receive an belonging function, the value of which lies in the range from zero to one. Fourier transform for pattern recognition is used to obtain it. The network recognizes binary images. It takes complex numbers at the input, after which it approximates the function of belonging to the image.

Before recognition, algorithms are used to binarize and bring the target image to the general form. Then it is supplied completely to the artificial neural network with Fourier transformation. Separately, real and imaginary components are supplied full of parametric sequences of necessary and sufficient data of holograms of the target image, after which the image is recognized. The unambiguity of image recognition in different environments and different conditions is proved by the *uniqueness theorem*.

Uniqueness theorem. The integrable function uniquely defines the coefficients of the Fourier series or Fourier transform. The complete set of Fourier series coefficients or Fourier transform uniquely defines the corresponding function.

For processing layer-by-layer holographic information, a recurrent neural network with a Fourier row is used. Time domain convolution is used for frequency domain multiplication. The Fourier transform is used in machine additional learning with a model of reinforcement of one's own or another's, help to build fully parametric sequences of necessary and sufficient hologram data.

Multi-modal synergy of holographic neural network layers with additional training with new holograms allows, together with an ensemble of intelligent decision-making agents, to develop qualitative solutions [18, 19].

2.2 Spectral properties of intelligent digital twins

Control by intelligent agents to measure the properties and characteristics of electromagnetic radiation spectra of associative vibration communications by spectrographic equipment and other methods to obtain information about processes is a spectral property of intelligent digital twins. The most common types of spectroscopy are atomic spectroscopy, infrared spectroscopy, ultraviolet and visible spectroscopy, Raman spectroscopy, and nuclear magnetic resonance. The types of spectroscopy differ in the type of measured energy involved in the interaction. The central theory of spectroscopy is that light consists of different wavelengths and that each wavelength corresponds to a different frequency. The light spectrum described by the frequencies of the light it emits or absorbs appears sequentially in the same part of the electromagnetic spectrum during light diffraction.

Using absorption properties and in astronomy emission, spectroscopy can be used to determine certain states of nature. The use of spectroscopy in such different fields and for such

different applications has led to the emergence of special scientific directions:

(1) Study of the spectral emission lines of the Sun and distant galaxies;

(2) Space exploration;

(3) Redshift to determine the speed and movement of the remote object;

(4) Search for physical properties of a distant star or nearby exo-planet using the relativistic Doppler effect.

Cyclic processes of nature, such as changing seasons, are supported by associatively connected steadily rotating vibration communications. An important aspect of scientific research in the universe is the spectral measurement of association chains of stable vibration communications of observed global processes. Synergistic analysis reveals interactions of different types of energy in heterogeneous media. Spectral measurement and synergistic analysis of the global processes of the Universe will reveal many new, not yet open fields of science.

There are several main methods for analyzing signal spectra: dispersion-time method, interference, digital method of discrete Fourier transform, filtering method. The dispersion-time method is implemented in dispersion spectrum analyzers and is based on the use of signal propagation features in decelerating systems with phase velocity dispersion - dispersion delay lines. Interference method is implemented in re-circulation spectrum analyzers with comb filter for separation of spectral components. Digital analyzers implement a discrete Fourier transform algorithm. The filtering method consists in isolating the spectral components of the signal using a narrow-band filter either in series or in parallel.

The change in spectrum over time is represented by a spectrogram. For its construction, the Fourier window transform is used: the spectrogram is represented by consecutive windows of the spectra, and each of these spectra forms a column in the spectrogram. Time is plotted along the horizontal axis of the spectrogram, frequency is plotted along the vertical axis of the spectrogram, amplitude is displayed by brightness or color.

Intelligent digital twins can obtain spectrograms by rotating the hologram relative to incident radiation by a certain angle. Vibration coupling of spectrograms with holograms allows the use of neural network multilayer systems with additional training for processing spectrograms [20].

2.3 Holographic semantic memory

Based on a holographic model of the brain, Argentine physiologist Hugo Zucarelli investigated the auditory system that allows the creation of holograms of speech information. Holograms of speech information are stored in holographic memory used to recreate the holographic image.

Holographic memory stores a holographic image of a word, concept, rule, and abstract idea. Holographic semantic memory has a large number of storage options and methods for establishing links between concepts. Semantic memory is a highly flexible, reconstructive, associative, and multimodal system. This is critical for cognitive and neural dependencies of the mental lexicon.

A mental lexicon is a collection of word information that includes the actual meaning of a word, a semantic component, a syntactic component, as well as perceived and reproducible forms of words [20]. In the mental lexicon, the neural network searches for and recognizes syntactic units and semantic connections.

Morphemes are considered the smallest unit - minimal sense-containing units. These are roots, suffixes, prefixes. At the same time, the mental lexicon can have several levels, and on one of them the minimum unit will be the word. Each unit is associated with many others. The essence of such an organization is that words related in meaning are often used in one thought situation. The more often words are used together, the stronger the connection between them, the greater the tendency to follow this connection during the associative process. Freud's invented method of free associations confirms this.

The mental lexicon does not have one organizing principle, but several at once. The master is semantic, that is, connections are made by meaning. The importance of this principle is proved by the semantic priming effect; in Russian-language literature, the term antecedent effect is used.

The mental lexicon is the central link in the organization of speech information. Each word is present in semantic memory in all grammatical forms, such as verb tenses or adjective genera. This extracts both semantic and syntactic information at the lexical access stage. When the word "red" is called, the names of other colors, objects of red color and others associated with it are activated in the semantic network (Figure 1).

Lexical selection is the stage at which, among all activated word forms, the most suitable is selected. Lexical integration is the union of all words into larger structures: collocations, sentences, up to whole internally connected texts. Preparation of texts includes macro- and micro- planning.

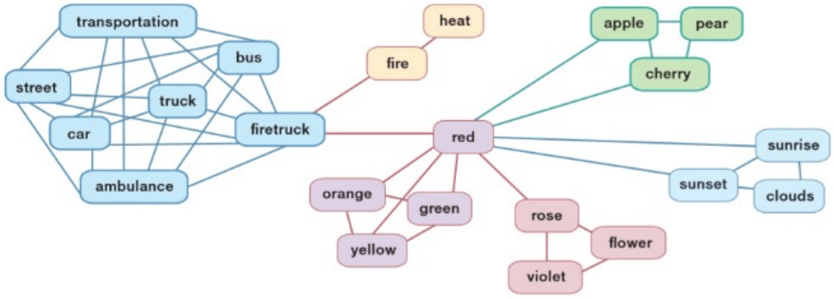

Figure 1 Semantic principle of mental lexicon organization

In microplanning, a question is developed as to how the information should be presented: which group of words to use, in what relationship to put them. After preparing the message, the output is a "concept", the general meaning of the whole sentence.

The formulation of expressions is giving the sentence a specific form, grammatical and phonetic, ready to pronounce. The concept obtained at the first stage interacts with the mental lexicon. At the output, we get the corresponding lemma - the initial form of the word. Many different word forms are associated with the lemma. According to the grammatical principle, lexical selection of word forms takes place. Next, morphemic analysis takes place. The resulting word will need to be called, the preparation for which becomes phonological analysis: analysis of the number of syllables and the stress position in the word. Thus, semantic memory is divided into syntactic and semantic categories.

3 5G holographic communication of intelligent digital twins

5G fifth-generation communications networks with big data analysis are designed to become one of the main holographic communication systems for digital twins with ensembles of intelligent agents [21,23].

The ensemble of intelligent agents in real time is able to analyze large volumes of heterogeneous hologram data using multi-layered neural network with additional training systems to provide high-quality holographic communication [20].

Holographic communication over 5G communication channels with subsequent image recovery over transmitted holograms begins with formation of dynamic hologram at the input of communication channel. Then, in turn, radiation containing hologram information and coherent radiation spectrogram are transmitted through this channel at equal time intervals smaller than characteristics of communication channel parameters change. At the output of the communication channel, hologram information is projected onto a dynamic recording medium. Coherent radiation is delayed for a time equal to the time interval for transmitting hologram information, oscillations with an inverted wave front are formed from it and used to recover images from a hologram projected onto a dynamic recording medium.

According to technical essence, transmission of holographic information via 5G communication channels consists in transmission of interference patterns with subsequent image recovery from transmitted holograms. Image recovery from holograms is carried out using coherent monochromatic radiation. Restoration of the hologram by coherent radiation passed through the 5G communication channel with a reversed wave front makes it possible to eliminate distortions introduced during transmission through the communication channel carrying information about the hologram.

Holographic communication over 5G communication channels is carried out using optical holographic communication systems, and a means of communication between intelligent digital twins [15].

4 Conclusion

Humanoid intelligent digital twins combine intellectual agent ensemble, computer learning and digital holography and spectrography software with special data to create active digital rational copies. The digital copy, as befits artificial intelligence, is constantly self-learning and self-improving. To this end, the digital copy uses knowledge from people, intelligent systems, and the environment it is a part of. Human-like intelligent digital twins with holographic and spectral properties should be used in the formation and development of an economy with an energy economic equivalent [24–26].

Michael Greaves offered three of his demands that digital copies must meet. The first is to match the appearance of the original object. The second requirement is related to the behavior of the digital twin. The last and most difficult is the information that is received from artificial intelligence about the advantages and disadvantages of a real product. As Michael Greaves notes, when digital copies were introduced into use, even the criterion of external similarity was considered difficult to fulfill. Today, as soon as the digital twin is identical in the first parameters, it can already be used to solve practical problems.

Humanoid intelligent digital twins are a hybrid model (both physical and digital) that is created specifically for specific purposes, such as predicting failures, lowering maintenance costs, preventing unplanned outages and disasters, according to Colin J. Parris, Ph.D., vice president of software research at the "GE Global Research Center."

When we talk about intelligent digital twins, this system works in three stages: see, think and do. At the vision stage, we are talking about obtaining data on the situation and data from the environment. The next step to think is due to the fact that at this stage the digital twin for different requests can provide options for how best to act in a particular situation or what options are preferable for the implementation of the current task, which are based on the risks that these proposals can reduce them. The last step - to do - is directly related to the implementation of what needs to be done.

According to futurologist and theoretical technologist John Smith, so-called software agents will appear in the near future, who will predict the wishes in advance, the behavior of their real copy and will perform some actions for their human counterpart. The digital twin will be able to make purchases, make decisions, engage in social activities - in general, he will be able to do everything that we sometimes do not have enough time for. We will also be able to shift all the routine work to our double. In addition, according to John Smith, our digital clones will know our interests, preferences, political views and, if necessary, will be able to defend them, as they will have a more complete historical context and see the modern picture of the world as a whole. Jonah Smith remains optimistic and believes digital twins cannot replace humanity. They will simply become other versions of man who can rationally coexist with us. Digital twins will train each other, forming a community of active copies living at computer speeds.

An attempt is being made to reveal the essence of the digital twin as a subject of information ethics and identify the criteria for his ethical identity. The idea is expressed that the main imperatives of information ethics for a digital twin are principles based on the commandments "do not harm" "do not steal" and "do not lie," which receive a kind of refraction in the information space. They mean: "do not harm with digital viruses," "do not steal information" and "do not distort information."

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