Personal Digital Twins and Their Socio-Morphic Networks: Current Research Trends and Possibilities of the Approach[1]

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Abstract. The digital twin concept which occurred in industrial engineering, design and production, is increasingly being transferred to nature and a man. The article covers the special case of building digital twins that is twins of subjects that are created by the latter to replace themselves, for example, to help in any activity. The paper describes the features of such twins, the possibilities and ways of their implementation, highlights their ability to form multi-agent systems that are isomorphic to social networks. The article considers the set of tasks that can be effectively solved with the help of personal digital twins and the socio-morphic multi-agent systems formed by them. The article ends with a statement on the formation of a multidisciplinary research team for practice-oriented research in the field of personal digital twins and socio-morphic multi-agent systems built based on them and high-priority tasks of system prototyping.

Keywords: Digital twins, virtual digital assistants, social networks.

1 Introduction

The digital twin notion was introduced at the beginning of the 2000s, first of all, regarding complex industrial facilities and systems modeling [1]. More recently, however, it is also often applied to copying various objects of wildlife, including people [2].

Digital twins of subjects unlike of inanimate objects can be used not only as models but they can also act by themselves, as well as interacting with each other. This opens up new possibilities for using them to solve a wide range of different tasks.

2 Digital Twins: Options for Use

Digital twins: options for use. In inanimate nature, we have the following (main, primary) way of using digital twins (DTs). The owner of a physical twin, a device, a product, a process, brings certain issues on its current status and forecasts. These issues are addressed to a system that takes on the role of decision support. The digital twin operates within a decision support system (DSS), performing simulation modelling tasks. Simulation modelling by itself in the form of a numerical experiment is the main task of the DT in the modern (classical) sense. Additional features of DT, such as feedback or variability of DT during the life cycle, do not change the indicated main task.

When we transfer the digital twin concept to the wildlife, in many cases we can transfer the above-mentioned scenario. In fact, in many respects, a live object can be treated with the same task of determining and forecasting a state and considered as a special physical object. Thus, in [2] the task of using a digital twin to forecast the risks of health problems in a patient is discussed. Here, a physician, as a person concerned, addresses issues to DSS on the state and forecast of the patient's circulatory system, which are resolved using the digital twin of the latter.

Digital copying of a certain person or more generally a subject may be a special case. Here, since the personality has consciousness, it can set the task of creating its own DT and articulate issues for it independently. These issues may be of course similar to the forecasting physical health issues. However, there is a fundamentally different opportunity here, related to the fact that human consciousness has a different nature than the physical, even living world. Human consciousness acts both in the world of physical reality and in the world of virtual reality. In the virtual world, the DT can be used not to identify states and make forecasts, but to practically replace its "physical" twin, performing various activities for it, for example, communication interactions. We can say that something like this is in use in cyberspace: its world is filled with bots of different complexity, often simulating consciousness. If a person

has the opportunity to create his own digital twin like a kind of assistant bot, cyber assistant, the more accurate a digital copy is, the more profitably he will be able to use it. We will hereinafter call such digital twins, created by subjects in their own image and used as their virtual assistants, personal digital twins.

3 Digital Twins of Subjects in Science Fiction and Futurology

Digital twins of subjects in science fiction and futurology. Setting the task of at least even partial replacement of a natural person in communication, we face a problem that is rather sensitive for European culture. The very idea of applying the notion of a digital twin to a human person arises at the intersection of robotics and science fiction, where it has negative, even apocalyptic, connotation and can be considered as a continuation of the romantic tradition of the 19th century, a tradition where the foundations of the fiction were laid. The image of the twin-shadow, the twin-mirror image, taking possession of all the social binds of the original personality, is often found in the books of romantic writers. It should be considered that, in general, the interest in the problematics of personality in European culture is very closely connected with the romantic movement of the 19th century, and that the romanticism inertia is especially high in science fiction. For example, adaptation of the idea of taking the personality binds by a twin to the reality of digital technologies is as follows: “Before long personal software agents, also known as digital twins, will serve as our digital personal assistants. A personal software agent is a digital simulation of your personality - your values, interests, and goals. It's an idea that's had many false starts - in 1987, Apple made a concept video suggesting one was only a few years away - but is now resurfacing with a vengeance. Imagine if the more you interacted with agents Cortana or Siri on your smartphone, the less your phone acted in a manner consistent with its default programming, and began acting more like you - to the point where your digital twin could screen your calls, prioritize your “to do” list, even compose simple emails for you. If your personal assistant scanned your emails, blogs, and social media posts, your agent might even reflect “you” immediately upon startup. Your assistant may even interact with the assistants of others to streamline everybody's lives - but we must be cautious not to offload too much of ourselves into our digital assistants”. Further, in connection with this latest threat, let us consider the Her movie of 2013. [3]

The personal software agent from this sci-fi movie, but today being perceived as a realistic assumption, raises the same fears as the twin character of the romance. If its interaction with the owner’s social circle becomes too effective, it will appropriate the owner’s social binds and become autonomous, as a result, if not physical, then the social existence of the original will be over.

Regardless of the positive or negative connotation, at the level of a concept, the idea of a digital twin of a personality is inevitably considered today in the context of business and production digitalization, where this concept is connected by such key categories as dynamics, procedurality and modeling. Moreover, it is modeling that becomes the source of cultural fears.

The consolidated definition of a digital twin as a process presents it as an ever-changing digital profile containing historical (memory) and current data about an object [4]. Other definitions relate to the idea of system modeling based on simulation rules for forecasting (production [5] of the human body [6]). The ideas of procedurality and modeling are combined in the definition of a digital twin as a digital dynamic model that fully corresponds to a physical object, which allows simulating all the features of its behavior [7].

The potential risk of a digital twin relates precisely to the possibility of object or process modeling and with the threat of loss of control over the model, which is equal to control over the modeling object. This problem, which is especially acute against the cultural fears traditionally strong for Europe and related to loss of personality, should be addressed in proposals for the development of personal software agents that somehow work with individual characteristics of human behavior.

4 Personal Digital Twins: Technologies and Opportunities

Personal digital twins: technologies and opportunities. Unlike science fiction and futurology, in the real world, creation of human digital twins was distributed rather limitedly. In most cases, this is an external task in relation to the personality, when modeling of desires, goals, and preferences of the personality is made by external players and without its participation (and consent). Thus, for example, targeted advertising is organized. The works on the creation of personal software assistants and virtual digital assistants are most closely related to the idea of creating a digital twin as a personalized tool to expand the subject's capabilities. The task for organization of programs to support the human activity with machine complexes was set in the 80s [8] under the name of personal program assistants. The development of this idea led in our time to the widespread use of programs for smartphones under the name of virtual digital assistants (VDAs), which in their development, unlike previous personal assistants, began to take into account the context of their work (for example, geolocation). The researches aimed at the development of functionality of training and self-training in VDAs are well-known. All this could constitute a movement towards giving VDAs the features of a personal digital twin. However, the main efforts in creating virtual digital assistants were focused to a greater extent on providing it with artificial intelligence and creating a voice interface, as, for example, in the well-known CALO project carried out by SRI International under the auspices of DARPA [9].

We think that the shift in emphasis in researches on making virtual digital assistants towards their greatest personalization, considering them as personal digital twins, can be a fruitful approach to the development of this

direction in the research of artificial intelligence. However, for progress in this direction, it is necessary to take into account several important aspects of VDA creation, which were left without due attention in empirical research, although, as can be seen from the above, they were partially addressed in futurological and foresight works.

First, the virtual digital assistant will inevitably develop in the direction of acquiring the features of a personal digital twin. Immersion in the context of the subject, which began by tracking its geolocation and recording the time of interaction, will develop. This will be followed by immersion in the meaningful context of the subject: his work, contacts, etc. The complication of tasks will require modeling "what would the owner do," studying his behavioral patterns etc., for the more in-depth building of the subject's digital twin. Efforts in this direction can be much more productive than interest in the development of abstract artificial intelligence in the VDA.

Second, the natural "habitat" of digital twins will be cyberspace, a "cloud". Today's implementation of virtual digital assistants as mobile applications for a smartphone is determined mainly by business environment and is interdependent with their weak personalization. The personal digital twin can no longer be considered as a replicable program associated with a specific device. It will be unique for the subject, be of particular value and be used regardless of the specific device (which, of course, does not exclude special opportunities for the digital twin - control various devices, including the subject's smartphone, for example, using subagents).

Third, the personal digital twins by implementing the activity of the subjects themselves will face the need to establish contacts with the user's counterparties. Such contacts are likely to largely coincide with social groups and networks of subjects. In those cases where the counterparties will have their own PDTs, direct contact will also be established between them. Thus, PDT networks can be made in the form of multi-agent systems of intelligent software agents. Such networks will mainly be isomorphic to real social networks. Just as real social networks consist not only of people but also of collective subjects, digital twins of the latter can also be included in the network of digital twins. We will call such structures of interacting digital twins socio-morphic. Such socio-morphic multi-agent systems, which allow combining the autonomy of nodes with collaboration, can be used to solve a wide range of tasks associated with collective functioning.

A certain functional analogue of such socio-morphic multi-agent systems is social networking services. Compared to the latter, we can assume that such systems are very difficult to build and are extremely resource-intensive. This could be a serious impediment for study since it could be difficult to check the reliability of the results. However, socio-morphic multi-agent systems are distributed in their organization and therefore can be built as open and heterogeneous. Socio-morphic multi-agent systems built on open formats and protocols can be freely expanded simply by adding new agents.

This, in particular, means that the system can start with a small cluster of simple agents and gradually develop to the largest scale system. There will be no scaling problems with this expansion, unlike closed centralized systems (which include social networking services).

5 Some Tasks for Socio-Morphic Systems of Personal Digital Twins

Some tasks for socio-morphic systems of personal digital twins. Turning to building the described above socio-morphic multi-agent systems, consisting of PDTs, suggests the choice of tasks in which the efficiency of such systems can be exercised in the best way, and the features of building and development are tested practically. Some tasks that are being considered and are likely to be in the focus of near research are given below.

5.1 Social Network Support

Practical use of socio-morphic multi-agent digital twin networks can be a competition with social networking services in support of real social networks. One of the important functions of the PDT will be participating in the owner's communications. Even modern VDTs can interact to some extent with the owner's contacts through social networking services. However, in cases where there are PDTs on both sides of communication, mediation in the form of a social networking service becomes optional, since PDTs, having a cybernetic nature, can organize interaction directly. In this case, it is possible to imagine the support of communication in a certain social network based only on the interaction of digital twins of the subjects of such a network. It seems that all the capabilities of social networking services used by community members can simply and effectively be implemented in a multi-agent system of digital twins. Certain problems may arise in that part of the functions of the social networking service where general information about the service users' community is integrated and analyzed. However, this is primarily a way of service monetization by its owners. Individual community members are not directly interested in this functionality.

Of course, social networking services have certain attractiveness, thus serious arguments and concernment of the participants of these networks will be required to transfer the social networks communication to the base of multi-agent digital twin systems. The fact that standard social networking services have already had developed communities with millions of users and adjusted business model will work in their favor.

However, it is necessary to take into account that the existing social networking services have a number of shortcomings and limitations, as was repeatedly indicated, for example, in the well-known speech "Freedom in the Cloud" [10]. Support for social networks based on multi-agent systems is free from these shortcomings. Moreover, in some cases, the ability to select and increase the agent's functionality can be attractive, since the openness of the

system in combination with extensible protocols allows agents to operate in the same multi-agent system with various extensions of the basic capabilities.

The issues of comparing classical social networking services and social networking services based on multi-agent systems of personal intelligent agents were discussed by us earlier in [12, 13].

5.2 Building Knowledge Management Systems

Socio-morphic networks of digital twins can also be useful for the critical task of knowledge management (KM). The issues of knowledge management have been in focus of research for over 40 years. The main practical task is building knowledge management systems (KMS) that provide accumulation, systematization, preservation and reuse of intellectual, knowledge capital (organization). Herewith, effective solutions suitable for wide use have not yet been found. Creation of workable systems is practically available today only to industrial giants with almost unlimited financial capabilities, such as Nokia, Toyota, Rosatom. Such solutions are unique and poorly replicated in practice. At the same time, the relevance of the task is only increasing, the capabilities of digitalized man-machine systems are increasingly covering areas of tasks traditionally considered exclusively human, thus, we can talk about the trend of transition from information technology to a new type of technology - knowledge technology [14].

One of the potential problems with KMS building can be determined by the following: on the one hand, there is a stable representation of a KMS as an organization level system; on the other hand, the owners of knowledge are often other subjects, specialists, experts, research teams, with their own interests. Filling of KMSs with knowledge is not within their direct duties and is considered as an overload. The solution to the problem can be a recourse to a promising approach of knowledge ecosystems [14], according to which knowledge management is considered as activity in a certain ecosystem formed by subjects, each of which works with knowledge and manages it within its needs and capabilities, and knowledge exchange ensures the efficiency of the whole process.

We may see that at the system level building knowledge ecosystems can be carried out on the basis of multi-agent systems of knowledge subject digital twins. Helping their foretypes in knowledge management will be one of the tasks of personal digital twins. However, organizing into socio-morphic multi-agent systems, digital twins can share knowledge, synergistically reinforcing each other. In this approach, the organization knowledge resource is created as an aggregation of knowledge relevant to it of all employees, departments, and collaborating organizations obtained in the interaction of digital twins of all these individuals. It seems that such a knowledge management process is more natural in the real world. In more detail, the issues of implementing multi-agent information systems to knowledge management issues were addressed by us in [15].

5.3 Personalization of Education

The task of making individual educational paths has been known for a long time and is regarded as one of the urgent problems of modern education. The search for solutions is mainly concentrated in loading the learning tool with some artificial intelligence that determines the degree of training and abilities of a student, followed by recording these data for choosing the complexity degree and type (verbal, audio, visual, etc.) of educational materials, pace of their presentation. A number of limitations of this approach should be noted. First, the personalization of education is replaced by the personalization of the learning process: the goal-setting of the student and the competencies already mastered by him are of the focus of consideration.

In the case where digital twins of students and agents of educational services are included in the interaction in some socio-morphic system, personalization of both education and learning process is possible. A digital twin, having the objectives, the competence map of the subject of education and the cognitive portrait (style) of a person, is able, first, to form an up-to-date educational program for its owner from many possible ones (i.e., an individual educational path), and, second, in interaction of teaching tools and systems with artificial intelligence, determine an individual educational path based on a significantly larger scope of knowledge about a person than in currently implemented solutions.

The possibility of using digital twins and their socio-morphic networks for the organization of educational reflection, which is a necessary condition and a basic mechanism for mastering new content and forming new abilities, should be considered in particular. [11].

5.4 Representation in Cyberspace

Representation in cyberspace. Today, much of the activities of most subjects are implemented in cyberspace. Herewith, an increasing proportion of contacts are not with subjects, but with cyber systems, or with their direct participation in the interaction. These cyber systems, achieving goals and objectives of their owners, collect and accumulate information about subjects, including for building their digital twins. As a rule, the ultimate goal of such an activity is to monetize this information. Such a situation causes reasonable concern, since the safety of personal space in such interaction is at risk, and in many cases, a man cannot compete with cyber systems. The solutions offered today are not encouraging and, as a rule, consist in building the same cyber systems external to the user in

which the “anonymization” of the user is declared. Examples are the DuckDuckGo project or the ability to work in incognito mode in some modern browsers.

An effective alternative to the direct interaction of the subject with cyberspace can be the inclusion of a personal digital twin of the subject in the interaction, which will shield the interaction of the subject with cyberspace as an intermediate cyber system. In many cases, PDT could recognize and shield various attacks and manipulations by external cyber systems during interaction with cyberspace.

PDTs will inevitably be included by developers and users in the context and mechanisms of cybersecurity. At the same time, it can be predicted that different development programs will be determined differently with respect to two trends, the first of which is alienation of man’s activity and information about him, accumulation and use of personal data about a man by third parties, and the second is personal protection of a man from digital monitoring and control, use of digital tools to block these actions. It can be assumed that certain types of PDTs will be created and used precisely as means of personal privacy and cybersecurity of people. For example, as twins, they can create false information about their original, put a smoke screen of information noise, or, for example, change (delete, distort, etc.) this information by connecting to digital channels of monitoring and collecting digital footprints of human actions. We can consider such use of PDTs as the unfolding of contradictions between totalitarian and liberal trends in the organization of society, alienated and taken into cyberspace.

6 Forming a Scientific Group and Immediate Research Tasks

It follows from the above that the issues of creating personal digital twins and organizing them into socio-morphic multi-agent systems are an interesting and relevant line of research and may have immediate practical value lying in the field of social engineering (in the classical sense of B. Skinner).

A feature of these studies crucial to success will be the ability to make effective interaction between representatives of various areas of expertise, both the humanities and computer science and information technology. In fact, designing a model of a personal digital twin and determining ways of organizing such twins in socio-morphic networks will require competencies in a wide range of humanities, including philosophy, sociology, psychology, culturology, etc., and implementation will require competencies in the field of computer science and information technology, first of all in the areas of artificial intelligence and personal software assistants, distributed, open, multi-agent systems, knowledge management systems and decision support systems.

The Novosibirsk State University is currently forming an interdisciplinary research team with strong involvement of young scientists and students with the focus on such issues.

The immediate tasks of the team are to design and implement a prototype of a personal digital twin, focused on the expression of the features of the scientific-educational activity, and to form from such twins a foretype of a socio-morphic multi-agent system for communication in the community of professionals with elements of knowledge management functionality.

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