Technology for Synergistic Solutions Co-Creation Based on Multi-Agents' Diversities Interaction

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Abstract

When developing smart technology or devices, used whether in manufacturing, retail, health or other enterprises to create an efficient business, smart home or Internet of Things, it is necessary providing constructive feedback from the users. In addition to already known practice, an innovative approach is proposed: at the initial/early stages of developmental process the designers, developers, manufacturers, users, and stakeholders are simultaneously involved in the co-creation of multidisciplinary solutions. This approach allows initially using competencies and taking into account capacity, interests and expectations of all participants in order to make truly synergistic solutions, thereby optimizing the entire process and eliminating unnecessary steps and time consumption. For this purpose, a scientifically based technology for synergistic solutions co-creation by vast diversity of agents is proposed, which involves the identification of a system-forming factor, a structure-content pattern and mechanisms of co-creation. This allows modelling, control, piloting, multidimensional measurement, dissemination, multiplication and sustainable development of the whole process. Efficient technology of synergetic co-creation is based on an eco-humanistic model of multi-agents' interaction, in which diversity is used as a driving force. The proposed approach can be used for synergistic interaction between human intelligence and artificial intelligence agents, which will create the prospect of eliminating the risk of confrontation, which is feared due to the intensive uncontrolled development of artificial intelligence. Such interaction can be supported by a system of digital techniques and tools, including: 1) database that self-develops in the process of multiagent interaction; 2) technique of superimposing ideal and real profiles of multiagent solutions; 3) interactive map of current state and changes based on decisions made; 4) continuum of multiagent solutions implementation with identification of terms and performers; 5) multiscale efficiency measurement system; 6) demonstrator of synergistic multiagent solutions at specific sites; 7) lighthouse: Atlas of interactive maps displaying the dynamics of sites development.

Keywords [1]

Internet of Things, Artificial Intelligence, IoT development, multi-agent synergetic solutions, co-creation technology, eco-humanistic approach, HI-AI agents' interaction, digital techniques and tools support

1. Introduction

Increasingly, when developing smart technologies or devices in manufacturing, retail, healthcare, business or everyday life, be it a smart home or Internet of Things (IoT) [1], there is a need to provide constructive feedback from users. Traditionally, Living Laboratory (LL) technology [2] is used for this purpose. In our opinion, for all its effectiveness, LL has limitations due to the behaviorist model [3] on which it is based. LL makes it possible to observe user's behavior and provide its measurement according to established criteria. Improved versions of LL technology include users-developers

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discussions and statistical processing of the data obtained. However, at the current level of development of technologies, both digital and communication, the possibilities for interaction between the users and developers have significantly expanded. It is believed that today there are technological and methodological prerequisites for ensuring interaction in the format of co-creation of innovative solutions by multi-agents, based on multi-actor/sector/disciplinary interaction. Moreover, with the rapid development of artificial intelligence (AI), the time has come for synergistic human-artificial intelligence agents' interaction.

The objective of this paper is description of innovative digitally supported model for providing co-creation of synergistic solutions by multi-agents based on their diversities.

2. Analysis of recent research and publications

An analysis of publications in the target area shows that while the importance of co-creativity is recognized [4,5], there are practically no specific developments built on truly scientifically based principles of organizing multi-agent synergistic interaction. It is believed that this is explained by the complexity of multi-actor/sector/disciplinary interaction, which requires an understanding of its system-forming factor, content-structure pattern and mechanisms.

There is also a fundamental reason associated with a change in the scientific paradigm [6,7], the reorientation of target science to impact-oriented with the introduction of human-centered criteria (see Figure 1) of social, moral, economic, and environmental safety. This paradigm changes the entry point into the problem of multi-agent interaction, since each agent is considered as a holistic person [8], and not just as the owner of a set of professional qualities and general competencies. This, in turn, changes the strategy, methodology and technology of co-creation [9,10]. It is believed that solution to both scientific and practical problems lie in the plane of eco-humanistic [11,12], metacognitive [13] and multidisciplinary [14, 15] approaches used in the context of a new research paradigm that provides multi-actor/sectoral/disciplinary interaction in order to develop synergistic solutions.

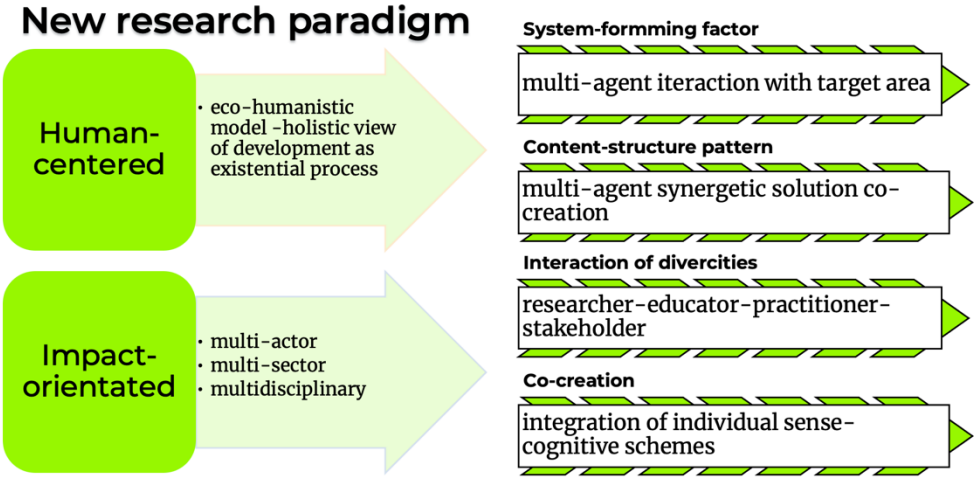

Figure 1: New impact-orientated and human-centered research paradigm

3. Approach, research methods and methodology

It is proposed to start the process by organizing synergistic interaction between designers, developers, manufacturers, users and stakeholders. This allows optimizing the process due to the initial strategic orientation towards the ultimate goal, ensuring the organization of actions into a system where the result of the previous action becomes the way to carry out the subsequent one. Optimization can be achieved not only through the initial organization of interaction, but also through the initial use of the existing resource potential of multidisciplinary competencies, taking into account the capabilities, interests and expectations of all participants to make truly synergistic multi-agent/sectoral/disciplinary solutions, thereby optimizing the entire process and eliminating unnecessary steps and time wasted.

The implementation of the proposed strategy is possible on the basis of scientifically proven technology for the co-creation of synergistic solutions, which is based on an eco-humanistic model of multi-agent interaction, in which diversity is used as a driving force for mutual development. Note that the proposed approach can be used both for human agents and for the interaction of human intelligence (HI) and artificial intelligence (AI) agents. HI - AI synergies can become a factor mitigating the risk of confrontation that is feared due to the intensive uncontrolled development of AI.

The essence of the eco-humanistic approach is that with the synergistic human-environment interaction, their mutual development occurs. Its efficiency depends on the capacity of the initial sense-cognitive orientation, which sets the intensity and amplitude of mutual development. Human ambivalent desire for preservation and development is realized through the balance of personal/social senses, resources and conditions. The process of human agent development occurs both internally (via consciousness with its cognitive, communicative and regulatory functions) and externally (via behavior), which are interconnected according to the feedback principle and have an isomorphic structure, including the action with its subject, object and conditions. All components of internal and external activity, depending on the type of interaction, can fall into both the zone of influence and the zone of dependence. When organizing efficient synergistic interaction, it is necessary to take into account the holistic system, with all its interrelations and interdependencies, in order to purposefully influence the process of co-creation, where the individual and socially developed experience is reflected in the objects and connections of human agent neural networks. HI - AI synergistic interaction is possible if the principle of organizing HI agent neural networks is integrated into AI systems with deep learning on the principle of organizing neural networks based on statistical analysis.

Multi-agent interaction aimed at co-creation of synergistic solutions becomes the driving force of co-development, which in turn requires an understanding of its nature, patterns and mechanisms. In order to model, simulate, pilot, control, measure, duplicate, disseminate and sustainably develop the process of co-creation, it is necessary to identify its system-forming factor, structure-content pattern (symbiosis of meaningful structure and structured content) and mechanisms. Figure 2 shows the structure-content pattern of multi-actor/sector/disciplinary co-creation, including: a) activity (A) – co-creation of innovative synergetic solutions; b) actors (S) – agents in a multi-actor/sector/disciplinary alliance including researchers, developers, designers, practitioners, users and stakeholders; c) object of activity (O) – multi-agent synergetic solutions; d) conditions of activity (C) – the possibility of making multi-agent synergistic solutions depending on actual state, functions, situations and circumstances of the environment that simultaneously is developing and being developed.

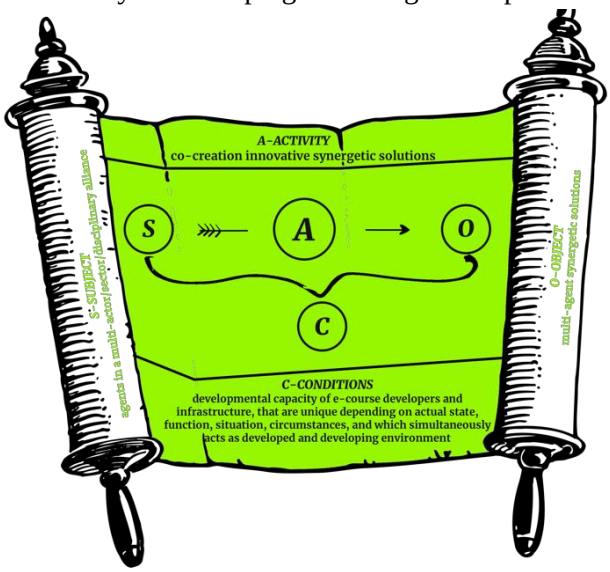

Figure 2: Content-structure pattern of multi-agent co-creation

4. Research Results

The eco-humanistic model allows simulating the existential process of multi-agent synergetic interaction in order to develop an efficient digital support system at each scientifically based stage of

multi-actor/sector/disciplinary solutions co-creation: 1) strategic sense-cognitive orientation of agents in the target area/product; 2) developing an ideal and real synergetic profile of multi-agent solutions; 3) mapping multi-agent synergetic solutions to an interactive map of the current state and changes/development of the target area/product; 4) system multiscale expert measurement of multi-agent synergetic solutions potential efficiency; 5) planning the implementation of multi-agent synergetic solutions with the definition of specific deadlines and performers; 6) piloting and creating patterns of multi-agent synergetic solutions; 7) efficiency assessment, adjustment and creation of demonstrations/lighthouses of multi-agent synergetic solutions in the target area/product.

The set of digitized tools (see Figure 3) includes: 1) the interactive database "OmniBase", which self-develops in the process of multi-agent interaction; 2) technology for overlaying profiles of multi-agent solutions; 3) an interactive map of the current state and changes in the target area/product based on adopted multi-agent synergetic solutions; 4) interactive continuum of multi-agent synergetic solutions implementation; 5) an interactive multiscale system for measuring the efficiency of multi-agent synergetic solutions; 6) technology for piloting and creating demonstrators of multi-agent synergetic solutions for specific target areas/products 7) technology for creating an Atlas of interactive maps reflecting dynamics of target areas/products development as sustainable development lighthouse.

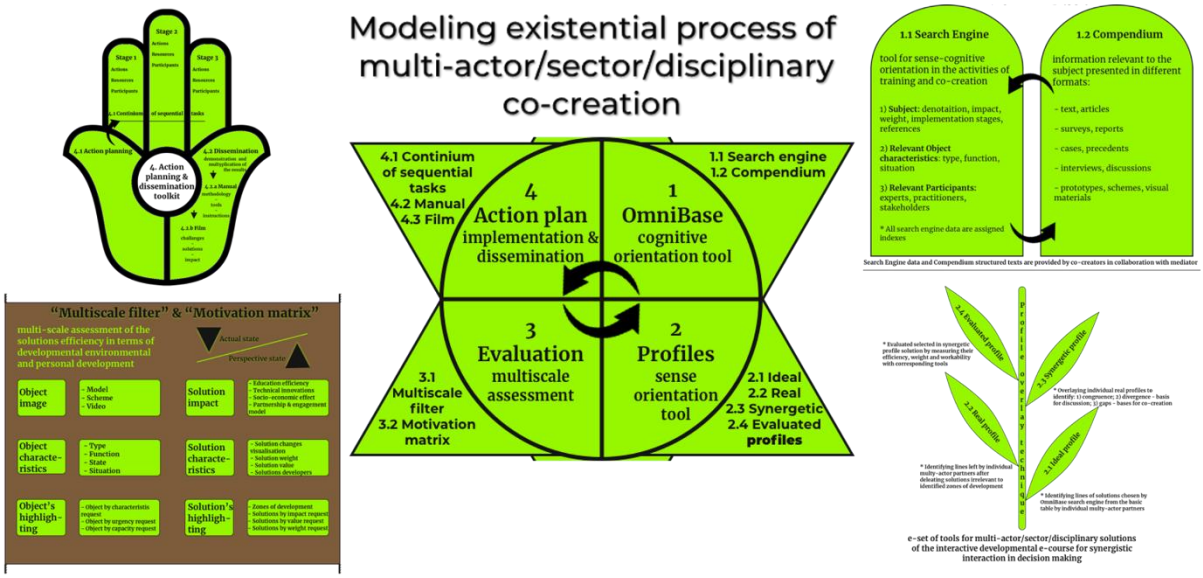

Figure 3: System of co-creation process digitized support

Let's consider the digitized tools in the logic of the co-creation stages. The biggest problem of multi-actor/sector/disciplinary interaction is the time-consuming and labor-intensive search for a "common language," which is explained by multi-agents' cognitive schemes diversities, both in content and level of development. Eco-humanistic technology allows providing effecient synergistic interaction of multi-agents via development of their cognitive schemes, which determine the development of neural network objects and links in the process of solutions co-creation. Such science-based development is supported by a digital tool that sets a strategic sense-cognitive orientation for the eco-humanistic development of solutions. "OmniBase" (see Figure 4) represents an interactive cognitive resource for orientation in the target area/product based on a generalization of socially developed experience. It includes:

(1) a search system for solutions that provides information upon request in the format of the structure of the co-creation process: (O) objects of co-creation: solutions in correlation with their potential efficiency, objects and agents; (S) multi-agent subjects of co-creation: experts – practitioners – stakeholders related to the target area of HR; (E) conditions of activity, specified by type, function and circumstances;

(2) a compendium of information relevant to the target field/product, presented in various formats (text, graphics, audio, video) in the form of articles, reports, case studies, interviews, precedents relevant to the field and structured according to the logic of search criteria.

(3) Co-creation involves true inclusivity, rather than formal or passive participation in making discussion or surveys. Such co-creation is possible only on the basis of the motivated activity of

all agents. The gradual development of such motivation is ensured within the framework of scientifically based eco-humanistic technology through the integration of sense-cognitive orientation into agent's sense-cognitive scheme, which is reflected in the development of objects and links of agent's neural network.

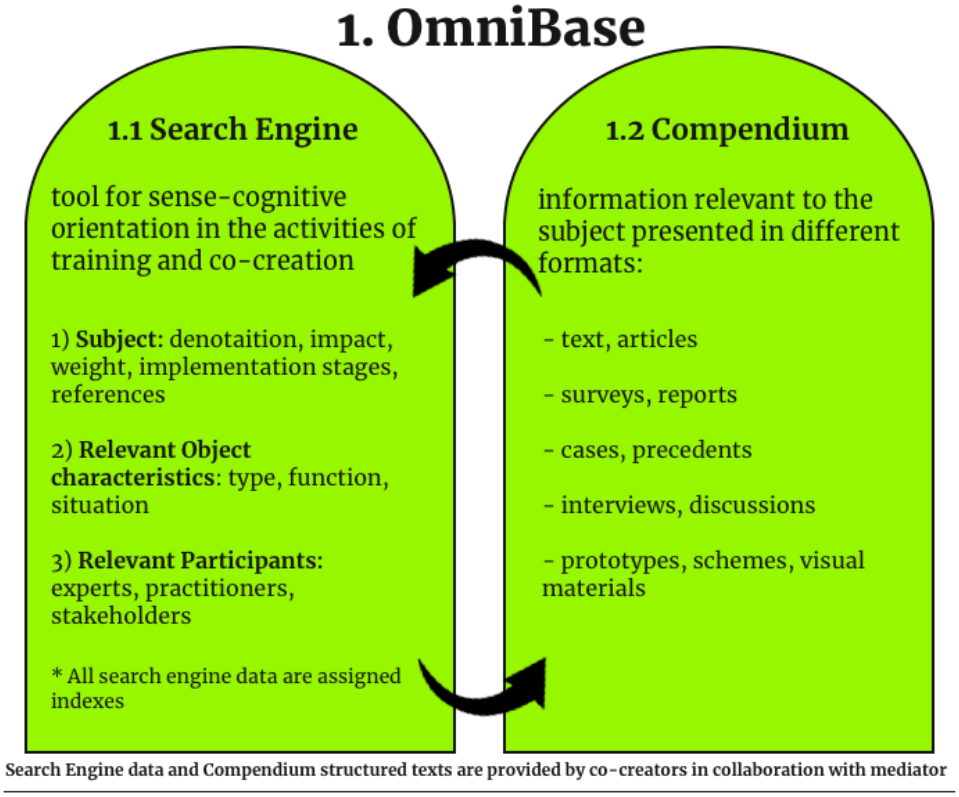

Figure 4: OmniBase for sense-cognitive orientation in co-creation

Such an initial strategic orientation determines the involvement of the agent, which determines the efficiency of solutions and personal development as a co-creator followed by self-identification with the decision made. The technology of engagement involves the following stages:

(1) through the specific task of constructing an "Ideal Profile" of the target area/product, the activities of multi-agents acquire not only a cognitive and sense orientation, but also involve them personally in the process of co-creation. The agent becomes a co-creator of the solution, identifying her/himself with it, which fuels personal motivation throughout the process of making and implementing the solution;

(2) through the task of constructing a "Real Profile" for making a realistic decision based on detailed familiarization with the conditions of a given object, the development of critical thinking of multi-agents occurs, which, in turn, develops both cognitive and sense resources that determine the quality of the solutions themselves;

(3) "Ideal Profiles" and "Real Profiles" are transformed into a "Synergetic Profile" based on the original technology of superimposing sense-cognitive structures, which allows solving one of the most difficult problems arising in collective decisions: the systematic integration of diverse solutions into a holistic synergetic solution without losing the uniqueness of individual solutions. Innovative digital technology allows the transformation of individualized profiles into synergistic ones, which enables the identification and evaluation of solutions based on the relationships, competencies and needs of multi-agents. The profiles are shown in the Figure 5.

Profiles reflect graphically: 1) an individual vision of multi-agents' ideal solutions, obtained by selecting solution directions from the basic OmniBase matrix through a query to the search engine ("Ideal Profile"); 2) an individual vision of multi-agents real solutions, obtained by identifying the lines remaining in the matrix after removing decisions that are irrelevant to the identified developmental zones ("Real Profile"); 3) an integrated vision of multi-agent solutions, obtained by superimposing

individual real profiles “Synergetic Profile” to identify: a) congruence as the basis for making a synergetic solution; c) diversity as the basis for discussions; 3) gaps as the basis for co-creation of a synergetic solution. In this way, technology allows us to identify similarities, differences and lack of solutions. The convergence of solutions in a synergistic profile allows to immediately evaluate, implement and disseminate a multi-agent solution. Differences signal a possible problem that can be efficiently resolved through cooperation. Gaps in the synergetic profile reveal the lack of solutions that can be developed within the same co-creation technology, repeatedly following the algorithm. Namely: resume the choice, but in relation to an object that has not received a solution. The iterative process will fill the identified gaps and arrive at a final solution.

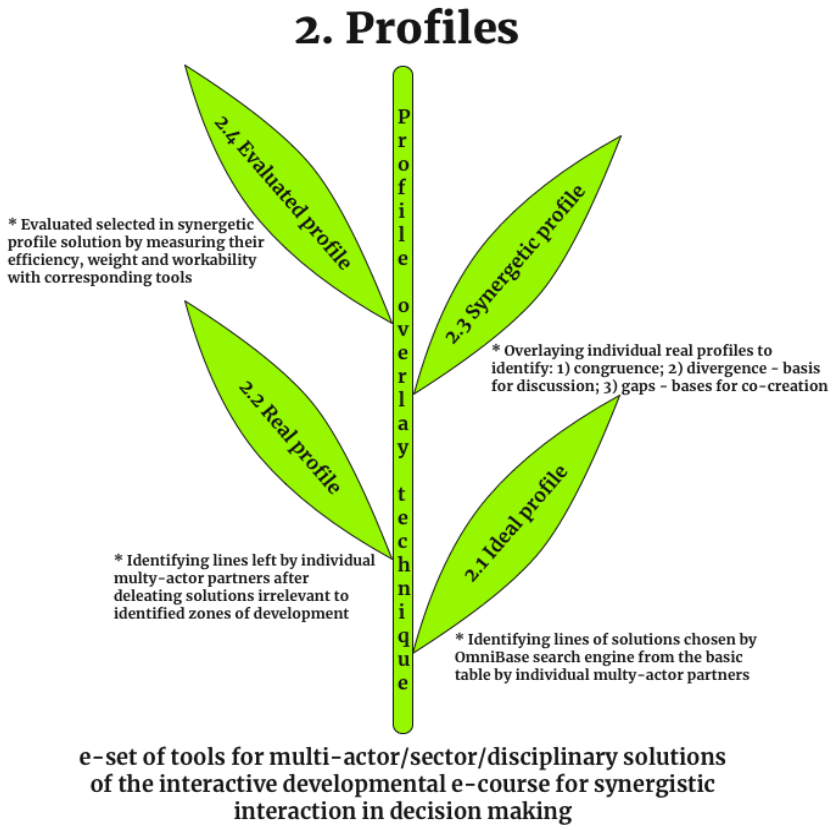

Figure 5: Set of Profiles for multi-agent synergetic solutions

The efficiency of multi-actor/sector/disciplinary solutions in the context of eco-humanistic development is assessed by using a set of e-tools including a multiscale filter and a motivation matrix (see Figure 6). Multi-dimension [16] is characteristic of existential holistic processes, determining the range of selection and evaluation criteria for the OmniBase search system as well as for evaluating multi-agent synergetic solutions. Their multiscale dimension is carried out in a dynamic “living” system of human-environment interaction and co-development.

The “Evaluated Profile” reflects the experts' vision of the efficiency, relevance and performance of solutions through multi-scale measurement with appropriate tools, including:

(a) "Multiscale Filter" - an original tool based on the profile overlay technique, allowing multiscale measurement of multi-agent solutions impact, efficiency, weight and performance;

(b) “Motivation Matrix” - an original tool based on the technique of superimposing profiles reflecting the hierarchy of human needs - existential survival, quality and sense of life [17].

It is also measured: the efficiency of solving problems based on a formula that includes the parameters of accuracy, speed and completeness; the complexity of sense cognitive schema based on the profile overlay technique; professional, social and existential senses as well as meta-abilities including meta-qualities proactivity, autonomy, objectivity, responsibility, flexibility, creativity and empathy) based on original questionnaires. The obtained data is processed by statistical methods [18], including correlation [19] and factor analysis [20], which determines relationships indicating possible causes, verified during a scientific development experiment.

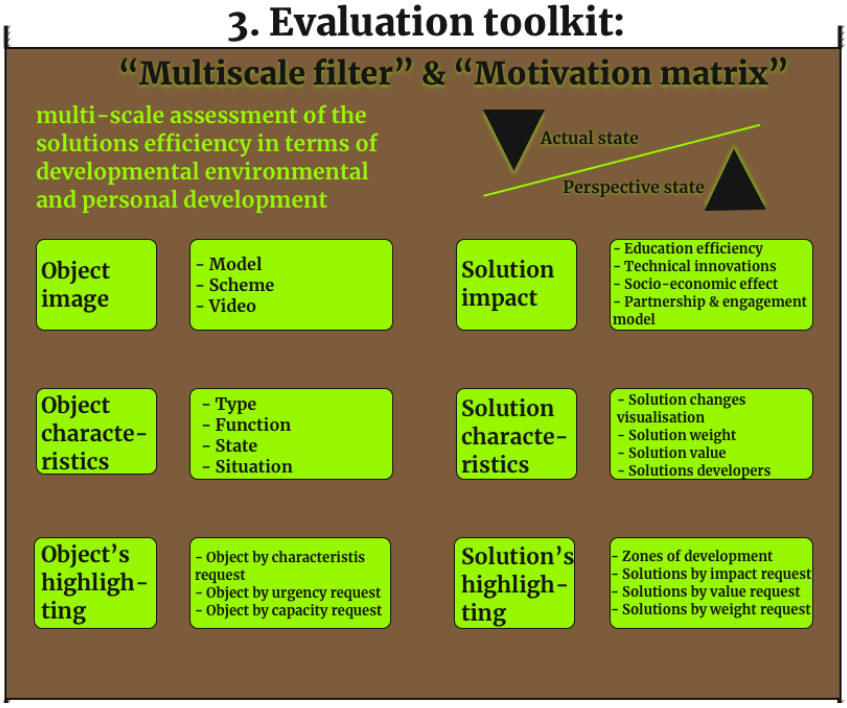

Figure 6: Multiscale evaluation of multi-agent solutions efficiency

Figure 7 reflects e-tools for planning the implementation of multi-agent synergetic solutions and dissemination of the results, including their demonstration and multiplication.

The evaluated synergetic profile of the multi-agent synergetic solutions is transformed into the "Continuum of Sequential Tasks" - an interactive e-tool for action planning in the format of visualizing the timetable of the process of implementing selected solutions, setting tasks and distributing responsibilities between agents. The "Continuum" organizes in a system the processes and activities of cocreation. Universal in format and unique in content, "Continuum" reflects the specifics of implementing solutions under existing conditions and available resources. "Continuum" demonstrates and disseminates solutions in the context of technological, socio-economic and social innovations.

A set of e-tools for disseminating results includes their demonstration and multiplication. The demonstration is carried out by creating an Atlas of interactive maps reflecting dynamics of target areas/products co-creation as sustainable development lighthouse. The demonstrator is accompanied by a dissemination toolkit, including: 1) "Expert Guide" providing technology - tools - interactive e-learning instructions based on a metacognitive approach; 2) "Film" for disseminating the experience to a wider audience, presenting information covering problems - solutions – impacts.

5. Concluding remarks

The creation of smart technological devices requires prompt feedback from users. To accomplish this task, Living Laboratory (LL) technology is used, which has significantly expanded its original functions of observation and direct data collection from users in a pilot experiment. Today LL are actively used for cooperative decision making by researchers, developers, manufacturers, users and stakeholders. However, the approaches used (discussions, questionnaires, teamwork, etc.) do not provide truly synergistic solutions and do not use recent technological capacity available. As an alternative, a scientifically grounded and experimentally tested innovative technology for multi-agent co-creation of synergetic solutions is proposed. The technology is based on an eco-humanistic model of multi-agent interaction, which uses diversity as a driving force. Defining a system-forming factor, a structure-content pattern in which the content is structured, and the structure is meaningful, and the mechanisms of interaction allows managing, simulating, piloting, measuring, multiplying, disseminating and ensuring the sustainability of the co-creation process. This approach involves designers, developers, manufacturers, users and stakeholders in its creation at the initial/early stages of the product development process. This allows not only to use multi-actor/disciplinary competencies and

take into account the capabilities, interests and expectations of all participants to make truly synergistic decisions, but also to optimize the entire process, eliminating unnecessary steps and time costs. This is possible due to the creation of an ultimate strategic orientation, which allows organizing actions into a system where the result of the previous action becomes the way to implement the subsequent one.

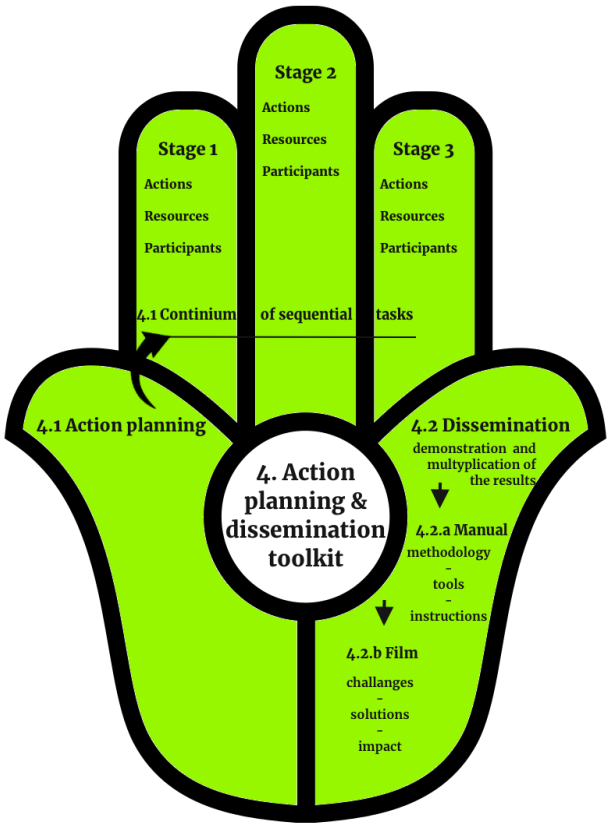

Figure 7: Toolkit for action planning and dissemination of multi-agent synergetic solutions

The proposed innovative model of synergistic solutions co-creation without loss of multi-agent diversity is supported by a system of digital technologies and tools developed in strict accordance with scientifically based stages of development and decision-making: 1) creation of a strategic sense-cognitive orientation of multi-agents in the target area/product; 2) personal involvement of multi-agents in the co-creation process through development of individual and synergetic solution profiles, based on multi-agents' competencies, integrated into their sence-cognitive structure and reflected in their neural network; 3) specification of multi-agents' understanding of changes causing transformation of a real area/product based on their solutions; 4) expert assessment/multiscale measurement of the potential efficiency of a multi-agent synergistic solution; 5) planning the implementation of a multi-agent synergetic solution with defining deadlines and performers; 6) piloting and creating patterns of multi-agent synergetic solutions; 7) assessment of real efficiency, adjustment and creation of a demonstrator/lighthouse of a multi-agent synergetic solution in the target area/product.

A digitalized technology/tool has been developed to support each stage:1) the interactive database "OmniBase", which self-develops in the process of multi-agent interaction; 2) technology for overlaying profiles of multi-agent solutions; 3) an interactive map of the current state and changes in the target area/product based on adopted multi-agent synergetic solutions; 4) an interactive continuum of multi-agent synergetic solutions implementation; 5) an interactive multiscale system for measuring the efficiency of multi-agent synergetic solutions; 6) technology for piloting and creating demonstrators of multi-agent synergetic solutions for specific target areas/products 7) technology for creating an Atlas of interactive maps reflecting dynamics of target areas/products development as sustainable development lighthouse. In perspective the eco-humanistic model can be used for providing synergistic interaction of human and artificial intelligence agents to prevent risk of confrontation arising due to the intensive uncontrolled development of AI.

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