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SIMULATING DISTRIBUTED CONSCIOUSNESS WITH SPATIAL GRASP MODEL

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Анотація. *Робота зосереджена на організації та управлінні великими розподіленими динамічними системами, що мають глобальну обізнаність та свідомість і ґрунтуються на іншій організаційній філософії, моделі та технології з використанням цілісного, саморозповсюджуваного, рекурсивного коду, а не на управлінні розподіленими системами як елементами, що обмінюються повідомленнями. У статті розглядається багато пов'язаних з ідеями свідомості існуючих робіт і публікацій, які з'являлися протягом століть. Вони групуються у різні категорії та супроводжуються короткими анотаціями до кожної з них. Узагальнюються основні ідеї Моделі та Технології просторового захоплення (ТПЗ), відображаються її загальні аспекти та описується Мова просторового захоплення (МПЗ) з її розподіленою інтерпретацією у відкритих мережах. У статті також порівнюються застосування ТПЗ і робота над мобільними агентами через попередника технології WAVE з використанням мобільності коду, а також підкреслюється, що розроблена просторова парадигма є набагато більш універсальною і потужною і що вона була введена в експлуатацію за багато років до мобільних агентів. Наводиться простий приклад використання МПЗ, який демонструє керування групою переслідувачів, що шукають розрізнені цілі, забезпечуючи її більшою обізнаністю і свідомістю, а також покращуючи її продуктивність. Ідея існування глобальної свідомості та навіть свідомості всієї країни вводиться шляхом представлення її як цілісності надзвичайно важливих компонентів, таких як економіка, суспільство, оборона, екологія та уряд. У статті також наведено кілька прикладів вирішення дуже практичних проблем, що виникають у сферах, за допомогою МПЗ. Обговорюються отримання та моделювання функцій, пов'язаних зі свідомістю, таких як глобальні почуття та думки, які можуть фундаментально вплинути на розвиток усієї системи. Надається підсумковий огляд потенційного застосування ТПЗ для різних категорій свідомості. Робота підтверджує ефективність просторової моделі та технології для моделювання різних особливостей усвідомлення та свідомості в різноманітних розподілених системах.*

Ключові слова: *глобальна обізнаність, розподілена та мігруюча свідомість, Технологія просторового захоплення, мережева інтерпретація, саморозповсюджувальні сценарії, співставлення просторових структур.*

Abstract. *This work is focused on the organization and management of large distributed dynamic systems supplied with global awareness and consciousness, being based on different organizational philosophy, model and technology using holistic, self-spreading, recursive code rather than managing distributed systems as parts exchanging messages. The paper reviews many existing works and publications related to consciousness ideas, which have been appearing for centuries, grouping them into different categories and providing short abstracts for each. It summarizes the main ideas of the Spatial Grasp Model and Technology (SGT) reflecting general technology aspects and its Spatial Grasp Language (SGL) with its distributed interpretation in open networks. The article also compares SGT with the work on mobile agents through its predecessor WAVE using code mobility and emphasizing that the developed spatial paradigm is much more universal and powerful and that it was implemented many years before mobile agents. A simple example in SGL that demonstrates managing a swarm of chasers searching for scattered targets, providing it with higher awareness and consciousness, and improving performance is provided in the paper. The idea of the existence of global awareness and even the consciousness of the whole country is introduced by representing it as the integrity of vital components like the economy, society, defense, ecology, and government. The paper also provides some examples of solutions in SGL to very practical problems in these fields. Obtaining and simulating consciousness-related features like global feelings and opinions is discussed, which may fundamentally influence the development of the whole system. A concluding summary is provided on the potential applicability of SGT for different consciousness categories.*

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The paper confirms the efficiency of the spatial model and technology for simulating different awareness and consciousness features in various distributed systems.
Keywords: *global awareness, distributed and migrating consciousness, Spatial Grasp Technology, networked interpretation, self-spreading scenarios, spatial pattern matching.*

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1. Introduction

The aim of this paper is to investigate the applicability and efficiency of Spatial Grasp Model and Technology developed and tested on numerous applications for expressing and simulating different ideas and capabilities of this mysterious and so far almost unknown feature called consciousness, despite numerous ideas of its existence and location, often controversial and fantastic, that have been offered and published for centuries. This work is particularly focused on obtaining consciousness features in large distributed and dynamic systems, which may cover economy, ecology, security, defense, as well as many other fields. The rest of the paper is organized as follows.

Section 2 reviews existing works and publications on consciousness and groups them into the following categories: definition and theory of consciousness, modes of consciousness, artificial consciousness, origin and features of consciousness, spreading and outside consciousness, Gestalt and pattern-based consciousness, consciousness and control, conscious and subconscious processes, collective consciousness, simulating consciousness using Spatial Grasp Model, consciousness in psychology and psychiatry, and international consciousness.

Section 3 briefs the main ideas of Spatial Grasp Model and Technology (SGT), reflecting general technology aspects, Spatial Grasp Language (SGL), and its distributed SGL interpretation, with more details available in numerous publications on this paradigm. It also compares SGT, through its predecessor version WAVE, with the work on mobile agents using code mobility too, emphasizing that the current paradigm is incomparably more universal and powerful and that it appeared and was implemented more than twenty years earlier.

Section 4 shows a very simple example in SGL for organizing and managing a swarm of chasers searching for scattered targets on different levels: discovering and eliminating targets at the shooting distance, sharing the seen targets with neighboring swarm members through embedded distributed awareness, and finally providing higher awareness and capabilities related to consciousness.

Section 5 discusses the potential capabilities of having awareness and even consciousness of the whole country by representing it as the integrity of vital components like economy, society, defense, ecology, and government. It shows some elementary examples in SGL that may relate to different components, like finding network images in a pattern-matching mode, outlining a specific region, and broadcasting executive orders via satellite network. Finally, some consciousness-related features are discussed using summary estimates obtained from different components, like generating important global feelings and opinions that may influence the current and future development of the whole system.

Section 6 contains a summary of the investigated potential application of SGT for different consciousness categories mentioned in Section 2. These are global workspace, knowing-feeling-acting, Gestalt and pattern-based consciousness, the origin and features of consciousness, spreading and outside consciousness, collective consciousness, and international consciousness

Section 7 concludes the paper with a strong belief in potential applicability of the developed spatial model and technology for expressing and simulating different consciousness features in a variety of important distributed and dynamic systems.

References include many analyzed sources on different consciousness features as well as existing publications on SGT and its applications which proved particularly useful for the conducted analysis.

2. Review of existing works on consciousness

Definition and theory of consciousness

Consciousness, at its simplest, is sentience and awareness of internal and external existence [1]. However, its nature has led to millennia of analyses, explanations, and debates made by philosophers, theologians, linguists, and scientists. Opinions differ about what exactly needs to be studied or even considered as consciousness. In some explanations, it is synonymous with the mind, and in others – an aspect of the mind.

The «hard problem» of consciousness asks why and how humans have qualia or phenomenal experiences [2]. This is in contrast to the «easy problems» of explaining the physical systems that give humans and other animals the ability to discriminate and integrate information, and so on. Such problems are called easy because all that is required for their solution is to specify the mechanisms that perform such functions.

Evolution has been the unifying theory of biology, but consciousness is rarely studied in the context of evolution [3]. Its theories come from religion, philosophy, and cognitive science, but not much from evolutionary biology. The offered theory suggests that consciousness arises as a solution to the problem facing any nervous system: too much information constantly flows in to be fully processed.

The term consciousness has eluded a precise definition for thousands of years [4]. Summary definitions of it fall short when it comes to capturing the dimensionality of the term. We might use the word «consciousness» to describe perceptual awareness, the nature of being awake and alert, or self-awareness and intentionality.

The conscious system is an open and dynamic one, interacting with the environment [5]. It has three functions: knowing, feeling, and acting (see Fig. 1). Human consciousness is dynamically constituted by the interactions between the three functions in time cycles.

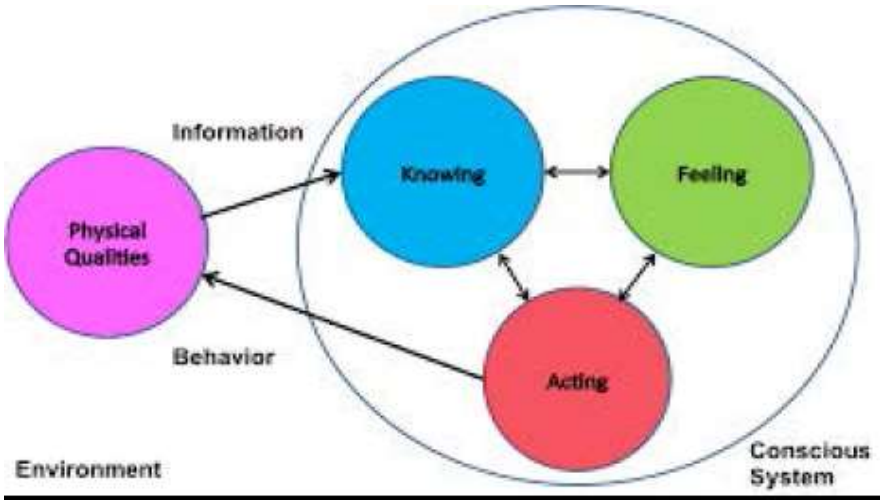


Figure 1 – Composition of a conscious system

Models of consciousness

Models of consciousness are used to illustrate and aid in understanding and explaining distinctive aspects of consciousness [6]. Sometimes, the models are labeled theories of consciousness. There are different types of models including mathematical, logical, verbal, and conceptual models.

A model of consciousness is a theoretical description that relates brain properties of consciousness (e.g., fast irregular electrical activity, widespread brain activation) to phenomenal properties of consciousness [7]. Because of the diverse nature of these properties, useful models can be either mathematical/logical or verbal/conceptual.

A mathematical model of embodied consciousness is based on the hypothesis that the spatial field of consciousness is structured by a projective geometry and under the control of a process of active inference [8]. This combines multisensory evidence with prior beliefs in memory and frames them by selecting points of view and perspectives according to preferences.

Artificial consciousness

Artificial consciousness (also known as machine consciousness or synthetic consciousness) is a field related to artificial intelligence and cognitive robotics [9]. Neuroscience hypothesizes that consciousness is generated by the interoperation of various parts of the brain, though there are challenges to that perspective.

The work [10] provides new insights into artificial intelligence (AI) and machine consciousness, with the perspective of AI added to this book edition. It shows that contemporary AI has a hidden problem that prevents it from becoming a true intelligent agent. A self-evident solution to this problem is given in this book.

Replication or even modeling of consciousness in machines requires some clarifications and refinements of our concept of consciousness [11]. The design, construction, and interaction with artificial systems can assist in this conceptual development. This activity may, in turn, nurture the development of our concepts of consciousness.

The work [12] introduces the concept of a virtual «Global Workspace» that emerges by connecting different brain areas to describe consciousness. In Global Workspace Theory, consciousness arises from specific types of information-processing computations, which are physically realized by the hardware of the brain (see Fig. 2).

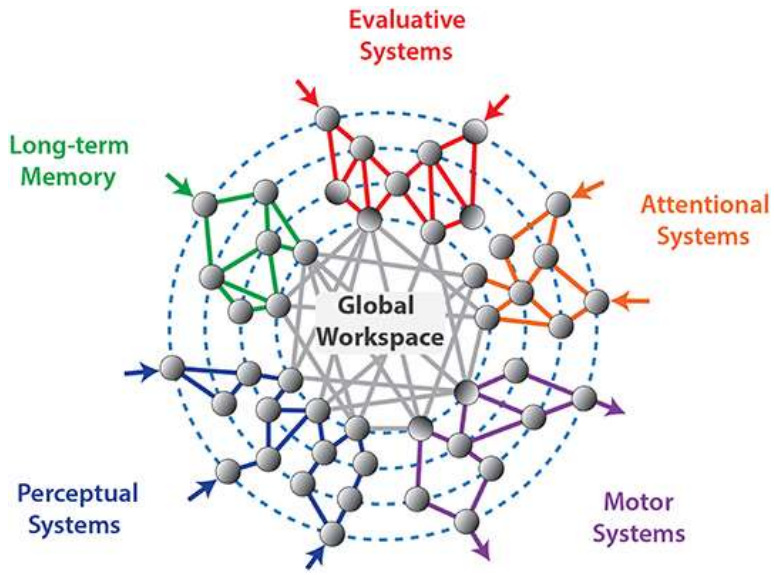


Figure 2 – The Global Workspace connecting different brain areas

Origin and features of consciousness

The work [13] analyzes whether higher spatial dimensions may hold the key to solving the hard problem of consciousness. The hard problem of consciousness is the most pressing unsolved mystery in both philosophy and science. To solve such a problem, we need revolutionary ways of thinking. There are arguments that higher spatial dimensions might have a solution to the hard problem.

How brain waves may create consciousness is discussed in [14]. At the root of all our thoughts, emotions, and behaviors, there is communication between neurons within our brain. Brain waves are produced by synchronized electrical pulses from masses of neurons communi-

cating with each other, and a brain wave is a repetitive or rhythmic neural activity in the brain. Brain waves are classified by different frequencies. Consciousness is considered a function of these frequencies.

To explain consciousness as a physical process, we must acknowledge the role of energy in the brain [15]. Energetic activity is fundamental to all physical processes and causally drives biological behavior. Recent neuroscientific evidence can be interpreted in a way that suggests consciousness is a product of the organization of energetic activity in the brain.

Spreading and outside consciousness

Spreading consciousness and awareness in the brain is discussed in [16]. Brain-scan images are iridescent icons of today's science of mind. Molecular changes inside the skulls get transformed into images sporting multicolored splotches, signifying pockets of heightened brain activity. These neural patches may be considered products of specialized brain structures that coordinate the mental process.

Whether consciousness can exist outside the brain is discussed in [17]. The prevailing consensus in neuroscience is that consciousness is an emergent property of the brain, and when the brain dies, the mind and consciousness of the being that the brain belonged to cease to exist. But some researchers now believe that consciousness persists after death and exists independently and outside of the brain.

What if consciousness is not an emergent property of the brain is discussed in [18]. The assumption in today's neuroscience is that all aspects of consciousness arise solely from interactions among neurons in the brain. But if consciousness entails more than the activity of neurons, then we can contemplate new ways of thinking about it. This review examines phenomena where consciousness extends beyond the physical brain and body in both space and time.

Whether consciousness and the world may be one is discussed in [19]. No convincing proof has been presented as to where exactly and how consciousness is placed in our bodies. Yet consciousness is real and, like any other real phenomenon, physical. The authors propose the radical hypothesis that consciousness is one and the same as the physical world surrounding us.

The idea of a science of mind wandering, empirically navigating the stream of consciousness, is discussed in [20]. Conscious experience is fluid; it rarely remains focused on one topic for an extended period without deviation. Its dynamic nature is illustrated by the experience of mind wandering, in which attention switches from a current task to unrelated thoughts and feelings.

Gestalt and pattern-based consciousness

The work in Gestalt often facilitates accessing what is held subconsciously, and the client sometimes moves into an altered state of consciousness, as in [21]. It releases the subconscious mind from what is trapped there and encourages the whole body and every cell to release pain. We become healthy in body, mind, spirit, and emotions as the process unfolds.

Linking consciousness with pattern recognition is considered in [22]. It is a phenomenological proof that pattern recognition and subjective consciousness are the same activity in different terms. Therefore, it proves that essential subjective processes of consciousness are computable and identifies significant traits and requirements of a conscious system.

Patterns of consciousness are discussed in [23]. Anyone who succeeds in business or society knows how to interact with complex human systems. They are able to see patterns, make sense of them, and choose. They act and make a difference for themselves and others. Whether they focus on family, team, organization, community, or nation, individuals and groups influence each other.

An introduction to patterns of consciousness is provided in [24]. Human consciousness naturally develops patterns as a way to be effective in its functioning in receiving, processing,

storing, retrieving, and transmitting information. This effectiveness was crucial for survival, especially for our ancestors, when they needed to respond to potential threats in a timely manner.

The idea that consciousness is a thing, not a process is discussed in [25]. The central dogma of cognitive psychology is that consciousness is a process, not a thing. However, the paper suggests an opinion that conscious sensory experiences are not processes at all. They are things, specifically spatial electromagnetic patterns, which in principle could be generated by hardware rather than wetware.

Consciousness and control

Representation of consciousness as control and controlled perception is given in [26]. The brain is considered a control system with its organization and functioning described and implications for the way we consider consciousness discussed. A phenomenon proposed by a massively interconnected network of sophisticated control systems that can produce language, imagine plan, and do many other things.

Conscious control over action is discussed in [27]. The extensive involvement of unconscious processes in human behavior has led some to suggest that consciousness is much less important for the control of action than we might think. This article pushes against this trend, developing an understanding of conscious control that is sensitive to our best models of overt action control.

The slogan «I am conscious, therefore, I am» is discussed in [28]. Organisms are adapted to each other and the environment because there is an inbuilt striving toward security, stability, and equilibrium. A general theory of behavior connects imagery, affect, and action with the central executive system we call consciousness. This assumes that the primary motivation of consciousness and intentional behavior is psychological homeostasis.

Conscious and subconscious processes

Conscious and subconscious processes of the human mind are discussed and compared in [29]. Conscious processing is partially done by unconscious processes and analysis of a great deal of information occurs outside of awareness. Consciousness has got some advantages that the unconscious does not have. Previous studies have shown that people are consciously aware of their implicit evaluations (Fig. 3).

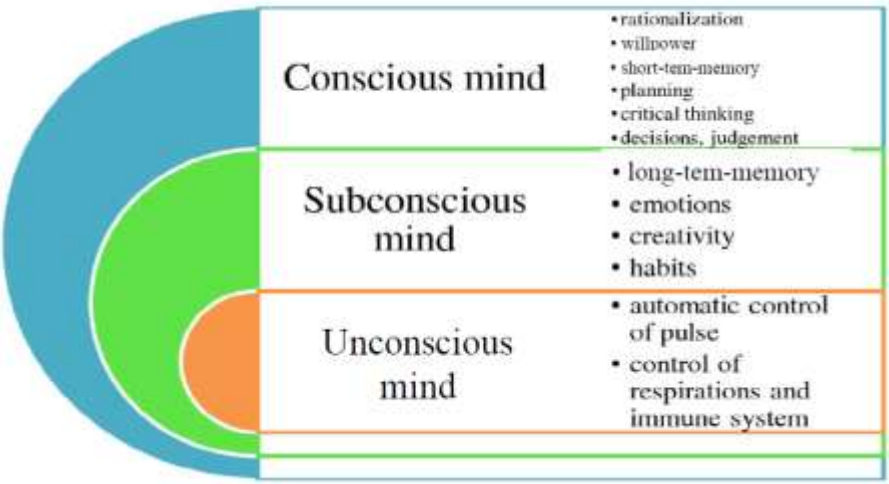


Figure 3 – Functioning of mind within a single brain

Collective consciousness

Collective consciousness (collective conscience) is a set of shared beliefs, ideas, and moral attitudes that operate as a unifying force within society [30]. Rather than existing as separate indi-

viduals, people come together as dynamic groups to share resources and knowledge. The modern concept of what can be considered collective consciousness includes solidarity attitudes, memes, extreme behaviors like group-think and herd behavior, and collectively shared experiences during collective rituals and dance parties.

Simulating consciousness with Spatial Grasp Model

The paper [31] is investigating the possibility of using Spatial Grasp Model and Technology (SGT) developed and tested in different countries for simulating global awareness and consciousness in distributed dynamic systems, with potential applications in intelligent system management, industrial development, space research, security, and defense.

The paper [32] shows how to simulate distributed and global consciousness using Spatial Grasp Language allowing us to obtain compact spatial solutions by directly expressing their top semantics. It first describes the traditional organization of two conflicting swarms (called chasers and targets) and then effectively provides the chasers with global battlefield awareness and consciousness.

The presentation [33] briefed Spatial Grasp Technology equally working with physical, virtual, and combined spaces and applications, including network theory, missile defense, collective robotics, command and control, industrial, social, and security problems. It shows how this model can be useful in understanding and simulating complex awareness and consciousness features.

Consciousness in Psychology and Psychiatry

How consciousness may relate to psychology is described in [34]. Consciousness is the individual awareness of our unique thoughts, memories, feelings, sensations, and environments. Our conscious experiences are constantly shifting and changing. For example, the next moment, we may notice how uncomfortable our chair is or mentally plan dinner.

Consciousness in psychology, theories, and examples is discussed in [35]. Consciousness is not found lying in physics equations or peering at us from the periodic table. Somehow it materializes out of the nervous system and endows us with the ability to be aware, have self-knowledge, and hold a set of emotions and beliefs about both the environment and ourselves.

The article [36] analyzes different meanings given to the notion of consciousness and shows how abandoning psychopathological controversies can lead to shallowness in the understanding of psychiatric pathology. It also highlights how different philosophical doctrines and psychological theories can be traced in every point of view which approaches the phenomenon of consciousness.

The psychiatric definition of consciousness (as in [37]) is the ability to be aware of oneself as an individual in relation to the surrounding world; the ability to correctly interpret one's own experiences. If the ability to self-identify or experience experiences is "altered", then it may lead to "qualitative disorder".

International consciousness

The problem of international peace is not materially different from the problem of peace in the individual, the community, or the nation [38]. Partially, it is a question at least of a state of mind. «As a man thinks in his heart, so is he» is as true of nations as of individuals. We can never be sure of world peace until we get an organization of international sentiment that will make for peace. Therefore, international conscience is the ultimate guarantee of international peace.

3. Spatial Grasp Model and Technology

Only the general features of the developed paradigm are included here, but there are many extended publications on its philosophy, features, organization, and numerous applications.

General issues

Within Spatial Grasp Model and Technology (SGT) [31–33, 39–53], a high-level operational scenario in a recursive Spatial Grasp Language (SGL), originating in a single or multiple world points, propagates, covers, and matches distributed environments in a parallel wave-like mode, as symbolically shown in Fig. 4. Such propagation can provide multiple local or remote results that are left where they were obtained or returned for higher-level analysis and decisions in order to launch new waves. These capabilities altogether provide holistic spatial solutions unattainable by other models and systems.

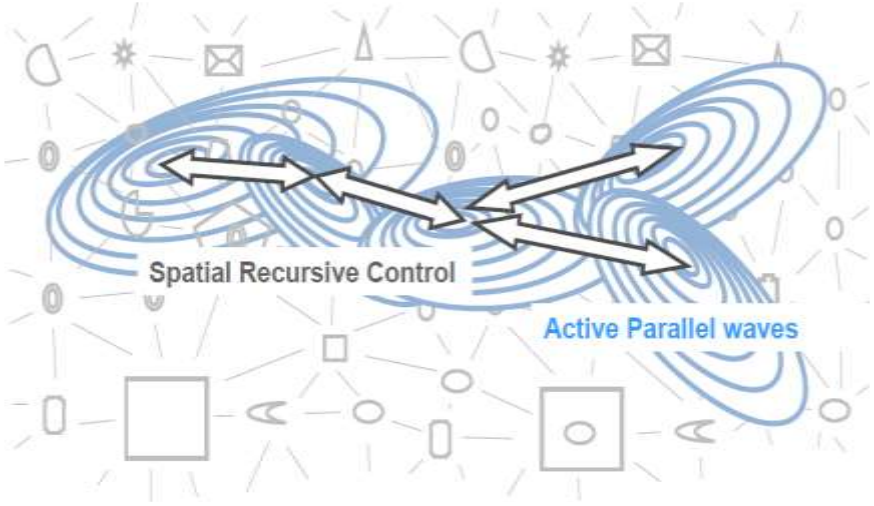


Figure 4 – Controlled parallel wave-like navigation of distributed spaces
under Spatial Grasp Model

Spatial Grasp Language (SGL)

SGL allows for expressing direct space presence, movement, and operations with unlimited powers and parallelism. Its universal recursive organization with operational scenarios called *grasp* can be expressed with a single formula

$$grasp \rightarrow constant \mid variable \mid rule\ (\{\ grasp,\ \}),$$

where *rule* expresses certain action, control, description, or context accompanied by operands, which can themselves be any *grasps* too. Top SGL details can be expressed as follows:

constant → *information* | *matter* | *custom* | *special*
variable → *global* | *heritable* | *frontal* | *nodal* | *environmental*
rule → *type* | *usage* | *movement* | *creation* | *echoing* |
verification | *assignment* | *advancement* | *branching* |
transference | *exchange* | *timing* | *qualifying*

Starting at certain points of the world, the rules can organize navigation of the world sequentially, in parallel, or any combinations. They can result in staying at the same application point or cause movement to other world points with the obtained results being left there, as in the rule's final points. Such results can also be collected, processed, and returned to the rule's starting point, with the latter serving as the final one for this rule. The points reached by the rule invocation can themselves become starting points for other rules. Due to recursive language organization, the rule can form arbitrary operational and control hierarchies and infrastructures expressing any sequential, parallel, hierarchical, centralized, localized, mixed, and up to fully decentralized and distributed algorithms.

Networked SGL implementation

Each SGL interpreter copy can handle and process multiple active SGL scenario codes propagating in space and between the interpreters. Integrated with any distributed systems and networks, the SGL interpretation network can form a spatial computer with unlimited power for processing, simulation, and management of distributed systems and worlds. Having a recursive self-spreading, self-controlled, and super-virus nature, this paradigm can dynamically establish and keep superior power over any system, including creating them from scratch and providing local and global awareness from any point to the same or other points, whether inside or outside the system.

Comparison with mobile agents and Telescript

A mobile agent [54] is a piece of software, combined with data, capable of migrating from one computer to another autonomously and continuing its execution in the destination place. A mobile agent is a process that can transport its state from one environment to another and be capable of operating in a new environment. In the early 1990s, the US company General Magic created the Telescript language [55] and environment for writing and executing mobile agents. The briefed above Spatial Grasp Model and Technology is also based on code mobility in computer networks but assigns this global feature to the whole programming system in which self-replicating parts of spatial scenarios can propagate in parallel in distributed environments and communicate under recursive spatial control, being also mobile. SGT keeps all functionality and power within a self-replicating virus-like code with unlimited power to create, modify, control, and manage any distributed systems that actually exist independently of them. This paradigm (originally called WAVE) appeared much earlier than mobile agents and Telescriprt (from the end of the 60s) and was practically used to organize distributed computations in citywide heterogeneous computer networks in Kyiv, Ukraine, well before the Internet [56–58]. The author of the paper visited James White, co-designer of Telescript, at General Magic in Seattle for the presentation of the WAVE technology (installed and operating at that time at UBC in Vancouver, Canada).

4. A simple example of distributed management up to spatial consciousness

It describes the organization of a swarm of chasers aimed at destroying distributed targets in some expected areas. We will consider the situation where the chasers are constantly moving, searching for, and destroying scattered targets that happen to appear at a shooting distance.

Discovering targets at a shooting distance and destroying them

The following scenario, activating all chasers in parallel, will do this, with chasers operating independently of each other (see also Fig. 5).

```
hop_chasers(all); nodal(Area = ...);
repeat(if(seen(targets),
    select_move_destroy(target),
    move_random(Area)))
```

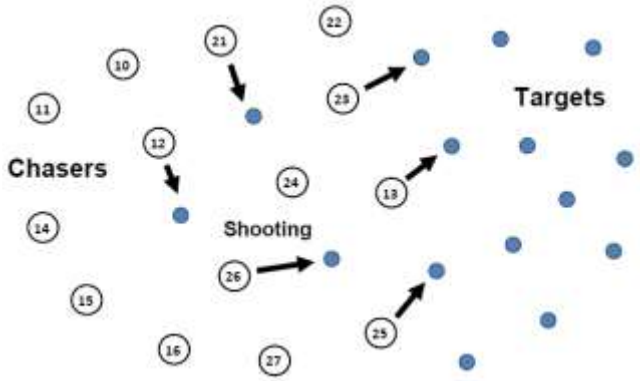


Figure 5 – A swarm of chasers attacking hostile targets in the expected area

Collecting the seen targets and sharing them with other swarm members

It works like the embedded distributed awareness of all targets somehow seen by individual chasers. In case there are no targets at a shooting distance, individual chasers can at least try to move toward the regions where potential targets are currently located in the hope to reach and shoot some eventually. And in the worst case, they can just move again blindly and randomly as in the previous case. This can be expressed in SGL as follows (see also Fig. 6).

```
hop_chasers(all); nodal(Area = ..., Global);
repeat(enrich(Global, search(targets));
 enrich((hop(all_neighbors); Global), Global);
 or_seq(select_move_destroy(Global),
  select_move(Global),
  move_random(Area)))
```

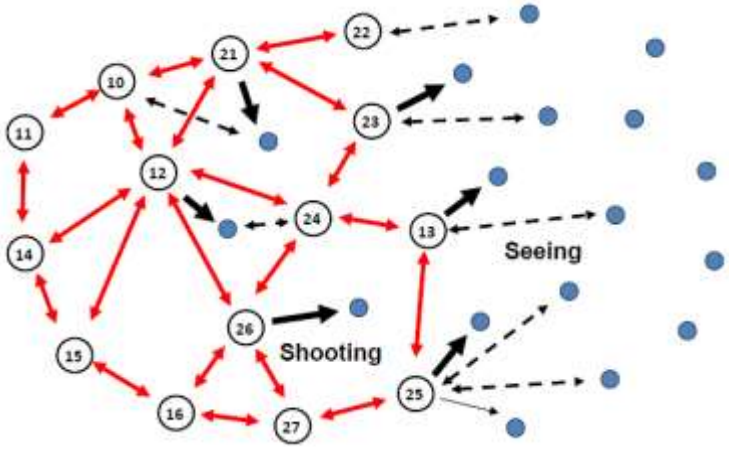


Figure 6 – Embedded distributed awareness of all targets seen locally

Introducing higher awareness, command, control, and consciousness levels

This includes collecting all targets in the operational area by a special high-resolution, long-distance vision system and enriching with this global data awareness of individual chasers, assisting their panning of movement to potential targets. It also includes assessing the global situation based on the current numbers of chasers and targets and the extension of the region they are operating in, and making higher-level recommendations and decisions for the whole mission. This can be accomplished through the introduction of a special global awareness, assessment, and feeling level close to the idea of consciousness (such higher-level capabilities may be permanently sys-

tem-embedded, freely migrating over the chasers' bodies, or outside ones like those owned by another system) (see Fig. 7).

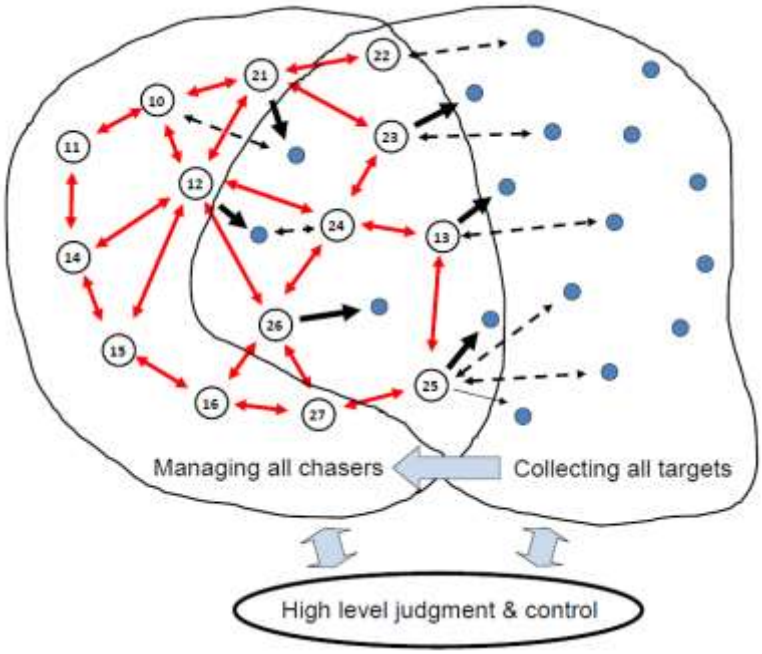


Figure 7 – Introducing higher-level collection, management, awareness, and consciousness levels

The following higher-level features may be possible in this direction:

a. Global awareness and management: collecting all targets by a higher-level observation system, enriching all actively and independently operating chasers with extended global data covering all operational areas.

```
frontal(Targ_all); nodal(Area) = ...;
repeat(stay(Targ_all = collect(targets, Area);
hop_chasers(all); enrich(Global, Targ_all));
 sleep(delay))
```

b. Generating feelings about the campaign rationale based on current global dynamic numbers, with recommendations of their increasing or decreasing.

```
Chasers_numb = count(hop_chasers(all));
Targets_numb = count(collect(targets, Area));
If(Chasers_numb < Targets_numb,
   increase(Chasers_numb, Area),
   decrease(Chasers_numb, Area))
```

c. More complex assessment and feeling including the current chasers and targets numbers, their comparison, and extension of the operational area, which may recommend even termination of the whole campaign as useless or too dangerous, believably altogether closer to a sort of global operational consciousness.

```
Chasers_numb = count(hop_chasers(all));
Targets_numb = count(collect(targets, Area));
if(and(Chasers_numb / Targets_numb < Threshold1,
 Chasers_numb <= Threshold2,
```

```
Targets_numb > Threshold3,
coverage(Area) > Threshold4)),
  or(reduce(Area), increase(Chasers_numb), terminate(campaign)))
```

5. Global awareness and consciousness of the whole society

As already mentioned in Section 2, collective consciousness is a set of shared beliefs, ideas, and moral attitudes that operate as a unifying force within society [30]. Also, international consciousness may not be fundamentally different from the consciousness of an individual, community, or nation [38]. We will discuss here briefly how SGT can be useful to express, simulate, and practically support higher-level organization up to the global consciousness of the whole country. The latter can be symbolically represented as the interaction of its key components strongly depending on and critically influencing each other, as shown in Fig. 8.

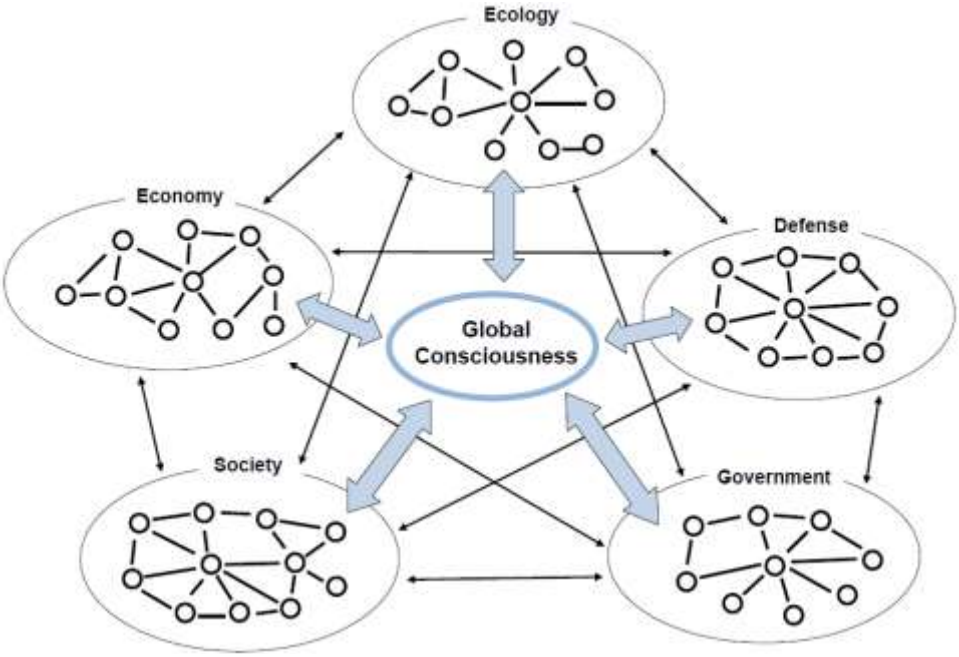


Figure 8 – Representation of the whole country as the interaction and cooperation of its key components

The meanings of the components represented in Fig. 8 are briefly described below with references to the related theoretical and practical problems having been investigated and tested by SGT for a long period of time and in different countries.

***Economy*.** It combines various institutions, agencies, entities, decision-making processes, and patterns of consumption that comprise the economic structure of a given community. Such a structure includes transportation and communications systems, industrial facilities, education, technology, housing markets, goods markets, and different banks, which enable a country or region to produce goods, services, and other resources. The related management examples in SGL can be found in [42].

Society. Societies are often characterized by social structures that include family, religion, law, economy, and class. This often contrasts with the notion of a social system which refers to the parent structure in which these various structures are embedded. Social structures significantly influence larger systems such as economic, legal, political, and cultural systems. Solving social problems in SGL can be found in [43].

Defense. Defense is usually associated with the armed forces which are divided into three military branches: army, navy, and air force. Internal security forces like gendarmeries, military police and security forces, paramilitary forces, militia, internal troops and police tactical units are

an internal security service common in most of the world. Different defense-related examples in SGL can be found in [41, 44, 46].

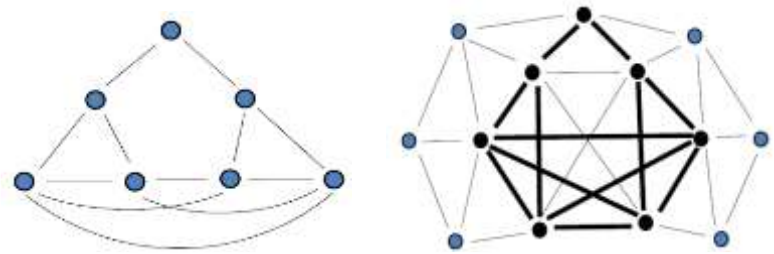
Ecology. An ecosystem consists of terrestrial and aquatic ecosystems. A terrestrial ecosystem includes forest, desert, mountain, grassland, and tundra ecosystems. An aquatic ecosystem is the one that represents a body of water. These can be further divided into freshwater and marine ecosystems. Examples of ecology-related solutions under SGT are given in [42, 47].

Government. It consists of executive bodies, judiciary, and legislature. The executive bodies often include a president, deputy president, and cabinet ministers at the national level, and premier and members of the executive councils at the provincial level. Judicial authority is vested in the courts which are independent and subject to the laws of the constitution. Legislature means a body of elected representatives that makes the laws needed for the government and the country to function. The related solutions in SGL are provided in [42, 44, 46].

Elementary examples of spatial SGL solutions

Only some elementary examples in SGL confirming the efficiency and simplicity of their expression under the Spatial Grasp paradigm (which are described in full detail in the mentioned SGT-oriented publications) are provided here. These may relate to the Workspace connecting different brain areas (as in [12] and Fig. 2), the unconscious and subconscious levels (like in [29] and Fig. 3), and knowing and acting functionalities (as in [5] and Fig. 1).

a. Processing network images. This example relates to spatial seeing of fully distributed networks and finding proper images-structures in them like the one in Fig. 9a, which may represent a two-level specific control hierarchy where all its bottom nodes are additionally fully interconnected with each other. A network with a positive match of the Fig.9a structure is shown in Fig. 9b, which may be obtained with the SGL self-matching pattern reflecting the image in Fig. 9a as follows.



a b

Figure 9 – Pattern matching in a distributed network: (a) an image to be found;
(b) a network with a positive match

```
hop_area(...);
hop_nodes(all); COLOR = NAME;
frontal(Fringe) = (hop_first(links, all);
 hop_first(links, all); NAME);
if(and_parallel(
     (hop_nodes_all(Fringe); remove(NAME, Fringe);
and_parallel(hop(link(any), nodes_all(Fringe)))),
   output("match found"))
```

b. Finding region border coordinates. The self-evolving virus-like SGL code spreading in parallel via the expected fire area picks up and returns coordinates of the reached border points, creating the final image of the region (say, representing forest fire) after collecting enough border coordinates (see Fig. 10 and [48–50] for the detailed description of such examples).

```
frontal(Zone_color = ..., Branches = ..., Start = ...);
```

```
hop(Start); nodal(Border);
parallel(
  hop_node(any, equal(COLOR, Zone_color));
  repeat(
    replicate(Branches, shift_random(dx_dy));
  if(nonequal(COLOR, Zone_color),
     done(append((hop(Start); Border), WHERE)))))),
  (sleep(...); output(Border)))
```

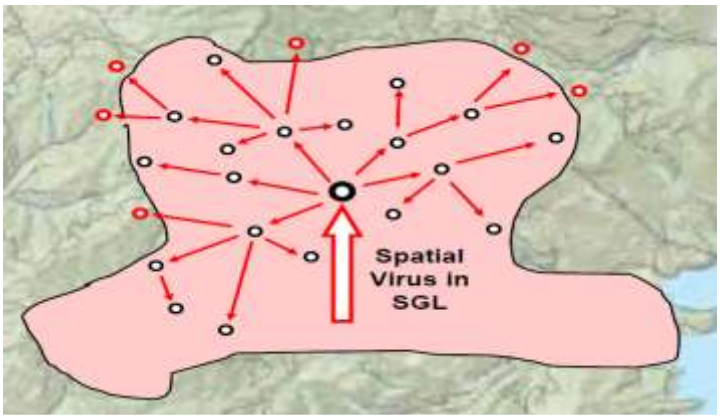


Figure 10 – Parallel virus-like outlining the border of the forest fire region

c. Broadcasting executive orders to a satellite network. Starting from the first reached satellite from ground station `G1`, the scenario below is broadcasts the given order to all other satellites via their dynamic network while blocking possible propagation cycles as in Fig. 11. Each reached satellite executes the order brought to it in frontal variable `Order`, whereas the parallel wave-like scenario simultaneously spreads to the neighboring nodes.

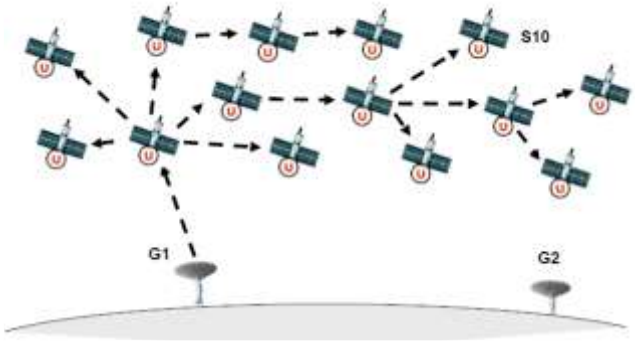


Figure 11 – Delivery of executive orders via a satellite network in a self-flooding mode

```
frontal(Order) = instructions;
hop(G1); hop_first_any(seen);
repeat(free(execute(Order)), hop_first_all(seen))
```

Expressing higher awareness and consciousness features

For such enormously large, highly developed, massively interconnected, and globally controlled distributed systems as shown in Fig. 8, we can offer an unlimited number of local and global understanding, assessment, coordination, modification, and management scenarios and separate examples, which may reflect a sort of symbiosis of their global awareness (as in [53]) and distribut-

ed and global consciousness. Due to the limitations of the length of this paper, we will show below only some of these possible awareness-consciousness solutions.

a. Obtaining some global numbers:

```
Production_all = sum(hop_area(Economy); hop_nodes(all); PRODUCE);
Consumption_all = sum(hop_areas(Economy, Society, Government, Defense,
  Ecology); hop_nodes(all); CONSUME);
```

b. Providing resultant global opinion and advice:

```
Above=Production_all – Consumption_all;
if(Above < zero, conduct(state-borrowing), OK);
```

c. Achieving integral global feeling and recommendation:

```
Consumption_mil=sum(hop_area(Defense); hop_nodes(al); CONSUME);
Defense_share=(Consumption_mil / Production_all) * 100;
If(and(Defense_share < 2, Above > 0), increase(Defense_share))
```

6. Summary of the simulation of different consciousness features in SGT

Detailed analysis of almost all existing consciousness concepts and ideas, like those discussed in Section 2 (reviewed from [1–38]), confirms the full applicability of SGT and its basic language SGL for their expression and implementation in fully distributed systems [39–52]. Some of these are mentioned below.

Global Workspace emerges (see Fig. 2 and [12]) by connecting different brain areas. This can be easily modeled in SGL by distributed physical-virtual networks with the existing and published repertoire of their creation, modification, and graph pattern-matching analyses.

Knowing, feeling, and acting represent the composition of a conscious system (as in Fig. 1 and [5]) as well as functioning of mind within a single brain as a hierarchy of the conscious mind (willpower, planning, decisions, judgment), subconscious mind (long-term memory, emotions, creativity), and unconscious mind (with automatic control) (see Fig. 3 and [29]). These can be expressed in SGL in a fully distributed manner, while preserving the high integrity of separate components and their deep integration and symbiosis.

Gestalt and pattern-based consciousness [21–25]. Expressing subconscious and conscious levels based on Gestalt psychology laws and pattern theory, allowing the human mind to grasp the whole first, can be effectively accomplished under SGT and SGL with the gained practical experience of doing related things in large, distributed, and dynamic systems with the use of active self-matching holistic images or patterns.

Origin and features of consciousness (like spatial dimensions, waves) [13, 14]. There are arguments that higher spatial dimensions might hold the key to the solutions to the hard problem of consciousness [2], or consciousness is considered a function of brain waves with different frequencies. All these ideas perfectly relate to the developed and tested Spatial Grasp Model and Technology that are fundamentally based on self-spreading parallel waves under recursive spatial control. But this paradigm also supplies spreading waves with additional power as they can carry themselves with the unlimited spatial functionality, being much superior to the systems they cover and from which they can be independent.

Spreading and outside consciousness [16–20]. The dynamic nature of consciousness is illustrated by the experience of mind wandering in which attention often switches from a current task to unrelated thoughts and feelings. Some researchers even believe that consciousness persists after death and exists independently and outside of the brain. Others propose the radical hypothesis that consciousness is one and the same as the physical world surrounding us. All such hypoth-

eses and ideas can be effectively expressed and implemented in SGL by creating powerful recursive scenarios that can unlimitedly self-spread, cover, match, create, and control both virtual and physical worlds, with numerous related examples already existing and published.

Collective consciousness, international consciousness [30, 38]. These represent a set of shared beliefs, ideas, and moral attitudes that operate as a unifying force within society. The problem of international peace is not materially different from the problem of peace in an individual, a community, or a nation. SGT has been used to describe numerous collective solutions, from the group behavior of animals or robotic swarms to large social systems, international management and security problems. Compact spatial SGL scenarios allow us to describe holistic distributed collective solutions on a high conceptual level and keep global control in complex situations, if needed.

7. Conclusions

This paper is concluded with a strong belief in the potential applicability of the developed spatial model and technology for expressing and simulating consciousness ideas and features. SGT can implement numerous consciousness hypotheses on a variety of levels, starting from creating artificial neuron systems with embedded network capabilities exchanging messages between neurons to simulating spreading waves between neurons, representing consciousness as freely wandering throughout and over the neuron structures, to fully self-contained consciousness outside the brain, to its existence independently in the whole world, even preceding its creation. Self-evolving active scenarios in SGL can keep all power and functionality inside their autonomous evolution in distributed spaces with full capability of expressing and simulating any consciousness ideas. The described technology can be quickly implemented and tested on any platform, as it was successfully experimented with in different countries with the author's engagement.

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