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Review Article

Relation of Spatial Grasp Paradigm to Higher Psychological and Mental Concepts

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Abstract

The paper analyses the relation of Spatial Grasp Language (SGL) and the developed Spatial Grasp Technology (SGT) to some higher-level psychological and philosophical concepts. By providing basics of SGL and SGT and details of their implementation, it then discusses possible relation of these concepts to some gestalt theory laws like the Law of Proximity, Law of Good Gestalt, and Figure/Ground Expression. The paper then shows how to organize a sort of distributed and global awareness under SGT onan example of a dynamic swarm of chasing units, which can provide increased operational capability of the swarm and be practically used for organization of collective behaviour of multiple robotic units exploring unknown and harsh environments. The paper also mentions how SGT may relate to much higher mental concepts like perception, consciousness, and even soul.

Keywords: Spatial Grasp Technology; Networked Implementation; Gestalt Theory Laws; Global Awareness; Consciousness; Soul; Collective Behaviour

1 Introduction

The aim of this paper is to investigate and show how the developed Spatial Grasp paradigm may relate to some higher-level psychological, philosophical and mental concepts, which may considerably increase integrity, intelligence, and practical capabilities of large distributed systems of both terrestrial and celestial nature. The rest of the paper is organized as follows. Section 2 describes main features of the Spatial Grasp model and its basic Spatial Grasp language, including their implementation and existing application areas. Section 3 discusses possible relation of SGT to gestalt theory laws, showing how to organize gestalt-based distributed vision under SGT using the Law of Proximity, by starting the space seeing from any single point or by many points in parallel. It also discusses the relation of the found results to the Law of Good Gestalt, by evaluating compactness of the obtained images in a group as their gestalt quality. The Section also shows how to simulate the gestalt's Figure/Ground Expression in SGL by finding a spatial figure surrounded only by spatial ground, and no other images, also finding and collecting all figure's border addresses. Section 4 shows how to organize a sort of distributed and global awareness under SGT on the example of a dynamic swarm of chasing units. This includes such examples as elementary swarming with only local awareness, deeply embedded into the swarm the overall awareness, and superior and migrating global awareness, Section 5 shows how SGL may relate to much higher mental and philosophical concepts including perception, consciousness, even soul. Section 6 concludes the paper.

2 Spatial grasp model and technology

The patented and extensively published distributed technology main ideas are briefed here, with many other details easily found in [1-11].

Spatial grasp technology basics

Within Spatial Grasp Technology (SGT), a high-level scenario for any task to be performed in a distributed world is represented as an active self-evolving pattern rather than a traditional program, sequential or parallel one. This pattern, written in a high-level Spatial Grasp Language (SGL) and expressing top semantics of the problem to be solved, can start from any point of the world. Then it spatially propagates, replicates, modifies, covers and matches the distributed world in a parallel wave-like mode, while echoing the reached control states and data found or obtained for making decisions at higher levels and further space navigation, as symbolically shown in figure 1.

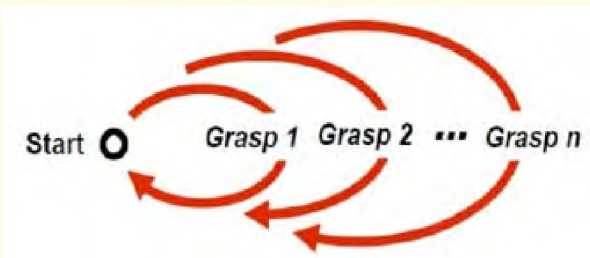

Figure 1: Spatial grasp model main idea.

The worlds SGT operates with

SGT allows direct operation with different world representations: Physical World (PW), considered as continuous and infinite where each point can be identified and accessed by physical coordinates; Virtual World (VW) which is discrete and consists of nodes and semantic links between them; and Executive world (EW) consisting of active "doers" with communication possibilities between them. Different kinds ofcombinations of these worlds can also be possible within the same formalism, like Virtual-Physical World (VPW), Virtual-Execution World (VEW), Execution-Physical World (EPW), and Virtual-Execution- Physical World (VEPW) combining all features of the previous cases.

Spatial grasp language syntax

SGL top-level syntax is shown in figure 2.

An SGL scenario, called grasp, applied in some point of the distributed space, can just be a constant directly providing the result to be associated with this point. It can be a variable

```
grasp     →  constant | variable | rule [({ grasp,})]
constant  →  information | matter | custom | special | grasp
variable  →  global | heritable | frontal | nodal | environmental
rule      →  type | usage | movement | creation | echoing | verification |
             assignment | advancement | branching | transference |
             exchange | timing | qualifying | grasp
```

Figure 2: Basic recursive structure of Spatial Grasp Language.

whose content, assigned to it previously when staying in this or (remotely) in another space point (as variables may have non-local meaning and coverage), provides the result in the application point as well. It can also be a rule (expressing certain action, control, description, or context) optionally accompanied with operands separated by comma (if multiple) and embraced in parentheses. These operands can be of any nature and complexity (including arbitrary scenarios themselves) and defined recursively as grasp, i.e. can be constants, variables, or any rules with operands (i.e., as grasps again), and so on. The full description of the latest SGL versions can be found in [4-11].

SGL rules

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

SGL variables

SGL Variables include Global variables (the most expensive and rarely used ones) which can serve any SGLscenarios and be shared by them, also by their different branches; Heritable variables appearing within a scenario step and serving all subsequent, descendent steps; Frontal variables serving and accompanying the scenario evolution, being transferred between subsequent steps; Environmental variables allowing us to access, analyze, and possibly change different features of physical, virtual and executive worlds during their navigation; and finally, Nodal variables as a property of the world positions reached by scenarios and shared with other scenarios in the same positions.

Elementary SGL programming examples

- add(7,8)– finds the sum of two values when staying in some world point and leaves the result there.
- assign(Result, add(7,8)) – the found sum of two values is assigned to a variable Resultwhich will be staying in the same point.
- move(x_y)– from the current world point provides a physical move to another physical pointwith the given coordinates.
- create(John)– there is created an isolated virtual node John.
- hop(John); create(+father, Peter) – there appears the extension of the existing single-node virtual network with a new node and relation to it, where John will be treated as the father of Peter.
- move(x_y); repeat(shift(dx_dy); TEMPERATURE > 0) – starting from the world point with proper coordinates, in the chosen direction there is organized a repetitive movement unless the temperature in the reached physical locations remains above zero.
- if(hop(Peter), create(Lilia, Olga, Ann)) – in case of the existence of virtual node Peter, there will be created three new isolated virtual nodes with proper names.

SGL spatial interpretation

Communicating Interpreters of SGL can be in an arbitrary number of copies, up to millions and billions, which can be effectively integrated with any existing systems and communications, and their dynamic networks can represent powerful spatial engines capable of solving any problems in terrestrial and celestial environments. Such collective engines can simultaneously execute many cooperative or competitive tasks- scenarios without any central resources or control, as symbolically depicted in figure 3 (SGL interpreters are named U as universal computational and management nodes which may be stationary or requested and runtime located in proper space points on the demand of SGL scenarios).

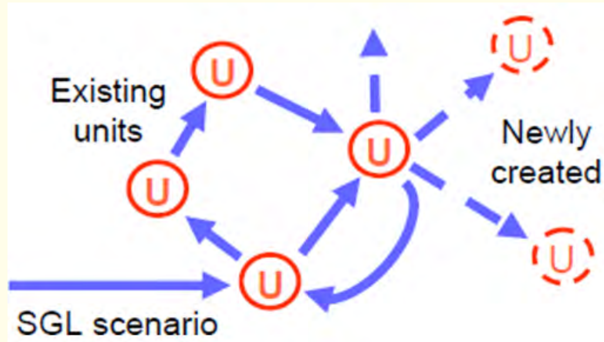

Figure 3: Parallel evolution of spatial grasp scenarios.

Investigated SGT application areas

The applications and resultant publications on this paradigm included such areas as intelligent network management, industry, social systems, collective robotics, military command and control, crisis management, national and international security, defense, distributed simulation, physical-virtual symbiosis, space-based systems, and even biology, psychology, and art, see also (the list is far from being full) [2-11], The developed concept was demonstrated at the universities of Braunschweig and Karlsruhe in Germany, Oxford and Surrey in the UK, British Columbia in Canada, Oita and Aizu in Japan, and California at Irvine in the US. A number of successful implementations had been made of this approach in different countries using such programming languages as Analytic, Fortran, Lisp, and C.

3 Gestalt-based distributed vision under SGT

Gestalt laws

The Section is linked with the Gestalt psychology and theory [12-19] emphasizing the unique capability of human mind to directly grasp complex images as a whole while interpreting parts in the context of this whole, rather than vice versa. Using SGT, it is possible to extrapolate these features to seeing and understanding structures and situations distributed throughout large spaces, and do this remotely and in parallel. The known gestalt laws include: Law of Proximity, Law of Similarity, Law of Continuity, Law of Closure, Law of Common Fate, Law of Symmetry, Figure/Ground concept, Law of Past Experience, Law of Good Gestalt, Uniform Connectedness (Law of Unity). The Section demonstrates in SGL only laws of proximity, good gestalt, and figure/ground controversy, while simulation of other laws in SGL can be found in [7].

Expressing the law of proximity

The Law of Proximity states that when individuals perceive an assortment of objects, they often first perceive objects that are close to each other as forming a group (as in Figure 4). According to the Law of Proximity, things that are near each other seem to be grouped together.

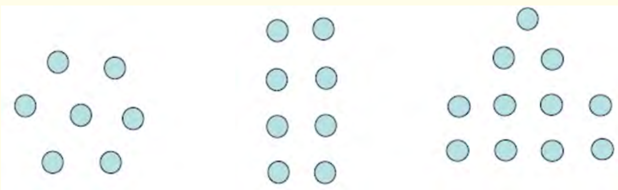

Figure 4: Proximity examples.

Let us consider how to practically express this law in SGL with orientation on finding groups of close to each other objects, like those in figure 4. We will be starting initially in a limited number of randomly chosenobjects, in hope that each may relate to a separate group, and then in all objects in parallel, using a Depth distance between objects allowing them to belong to the same group.

Starting from randomly chosen starting objects (each supposed to be in a different group)

Starting from each chosen object, in a spanning tree mode (with blocking cycling), the following scenario covers all objects having distances between them not exceeding the given Depth threshold. It then returnsall addresses of the nodes reached and collects them in the variable Group at the starting node, the content of which is printed in the starting node too.

frontal(Depth) = threshold; nodal(Start = 3, Group);

hop_objects(random, Start);

Group = repeat(done(ADDRERSS), hop_first(Depth));

output(Group))

The resultant groups are depicted in figure 5 (the starting nodes-objects are colored in red).

Starting from any number or all objects (some may be in the same group)

When starting to create a group from more than one point belonging to the same group, we may get duplicate group answers by the previous scenario. The following scenario variant may start from any number of visible objects in parallel, all of them including, and each group will be presented in the result only once. If simultaneous spanning tree coverage started from different nodes of the same group takes place, only a single spanning tree will be finally allowed to proceed. It will be from the node having highest value defined by its X-Y address, with immediate abortion of other trees, and the final group result will be issued in this strongest node.

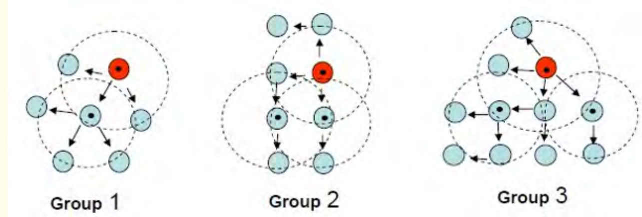

Figure 5: The discovered groups of objects.

frontal(Depth) = threshold; nodal(Group);

hop_objects(all); IDENTITY = ADDRESS;

contain(

Group = repeat(done(ADDRESS), hop_first(Depth);

if(ADDRESS < IDENTITY, abort));

output(Group))

Relation to the law of good gestalt

The Law of Good Gestalt explains that elements of objects tend to be perceptually grouped together if they form a pattern that is regular, simple, and orderly. This law implies that when individuals perceive the world, they eliminate complexity and unfamiliarity so can observe a reality in its most simplistic form. We will be using the simplest possible mechanism to assess the gestalt quality of the above obtained groups, just by the result of division of group's occupied square to the number of objects in it, as follows, see also figure 6.

frontal(Depth) = threshold;

nodal(Group, MinX, MinY, MaxX, MaxY);

hop_objects(all); IDENTITY = ADDRESS;

contain(

Group = repeat(done(ADDRESS), hop_first(Depth);

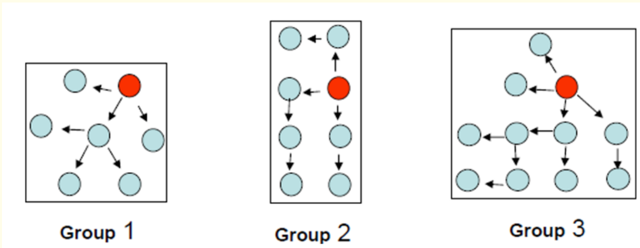

Figure 6: Assessing the good gestalt quality of groups.

if(ADDRESS < IDENTITY, abort));

(MinX, MinY, MaxX, MaxY) = analyse(Group);

Quality = (MaxX – MinX)*(MaxY – MinY)/count(Group);

output(Quality))The quality results will be: 276 for Group 1, 185 for Group 2, and 254 for Group 3. This finds Group 2 as the most compact, regular, and orderly.

Figure/ground expression

The Figure/Ground concept refers to the relationship between positive elements and negative space. The idea is that the eye will separate whole figures from their background in order to understand what's being seen. It's one of the first things people will do when looking at any composition. This principle shows our perceptual tendency to separate whole figures from their background based on one or more of a number of possible variables, such as contrast, colour, size, etc. Perception of figures and grounds can change from one to the other and then back, as in figure 7.

Figure 7: Examples of figure-ground perception.

A practical example chosen for figure-ground analysis

The picture to be analyzed in SGL is shown in figure 8, where the figure is expected to be in white, and the ground space should be grey. The object to be identified as a figure should only have borders with the ground, with any other combinations rejected. The scenario below is starting at some arbitrarily chosen white locations hopefully belonging to the figures, and then covers the remaining white spaces in parallel wavelike mode (implemented by self-growing spanning trees). If this coverage reaches all points painted only in white or grey (being stopped upon reaching grey ones), it indicates clear objects (like the one started from point 2 in Figure 8). It will be immediately rejected by reaching any other colors (like from point 1). The following solution options can be available.

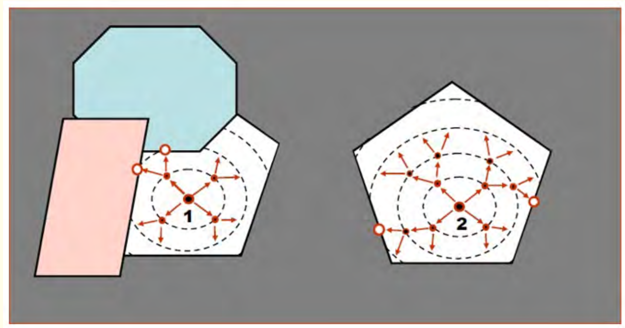

Figure 8: An example for resolving figure-ground controversy.

Confirming that we correctly pointed at the figure

The scenario will output addresses of all starting points that belong to the identified figures.

nodal(P1 = address1, P2 = address2, Next);

frontal(Extent = ..., Start);

move(P1, P2); CONTENT == white; Start = WHERE;

if(

repeat(Next = produce(Start, WHERE, Extent);

move_all(Next);

if(CONTENT == grey, stop);

if(CONTENT != white, abort)),

output(ADDRERS, " points at Figure")

Output of all figure's border addresses

The following scenario will output addresses of all reached border points of all identified figures.

```
nodal(P1 = address1, P2 = address2, Next, Border);
frontal(Extent = ..., Start);
move(P1, P2); CONTENT == white; Start = WHERE;
Border =
repeat(Next = produce(Start, WHERE, Extent);
move_all(Next);
if(CONTENT == grey, stop(WHERE));
if(CONTENT != white, abort));
output("Figure: ", Border)
```

4 Simulating Distributed and Global Awareness under SGT

The Section first provides a simple example of expression in SGL of a swarm of "chasers" which are constantly moving, discovering, and eliminating the distributed targets seen. It then supplies the chasers swarm with a sort of global awareness and even consciousness [21-36] over the whole operational area, which allows individual chasers and the swarm as a whole to improve performance. This global awareness may be deeply and naturally embedded into the communicating chasers s part of their regular functionality. It can also be organized as an additional, superior, level which may constantly migrate over and oversee the swarm body and the surrounding area, or even function as an outside supervision regularly activated from other systems.

Elementary swarming

We will consider here the situation where the operational swarm is consisting of chaser units named C1 to Cm, which can see (up to threshold distance D1), identify, move, and destroy reachable targets (which can move too), as in figure 9. In case no targets currently seen, each chaser may just wait for them or make a sort of random movement within the expected operational area unless some targets become visible.

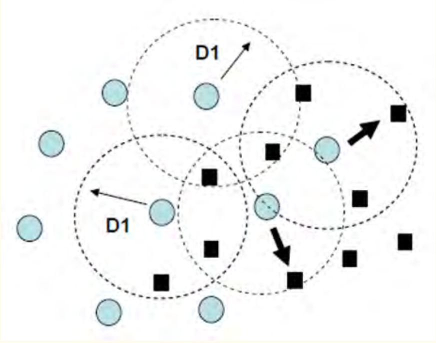

Figure 9: A swarm of chasers discovering and fighting distributed targets.

```
hop_nodes(C1, C2, .... Cm);
nodal(D1 = distance, Targets);
repeat(
Targets = search(D1); select_move_destroy(Targets);
sleep(delay))
```

With deeply embedded overall awareness

In the previous scenario, the chasers were operating in a fully distributed way, making individual local decisions to wait, move further, and attack targets seen. By enriching the swarm with a sort of global awareness over the operational area, we may essentially improve its performance locally and as a whole. We show here how this global awareness quality may be naturally embedded into the communicating chasers, where targets seen by individual chasers are regularly exchanged with their neighbors, enriching their awareness, and these neighbors, of all they know, exchange with their neighbors too, and so on. This makes all swarm members gradually becoming aware of all targets in the region, despite not all of them visible individually, and always organize their movement in proper direction (say, where most targets reside), see also figure 10.

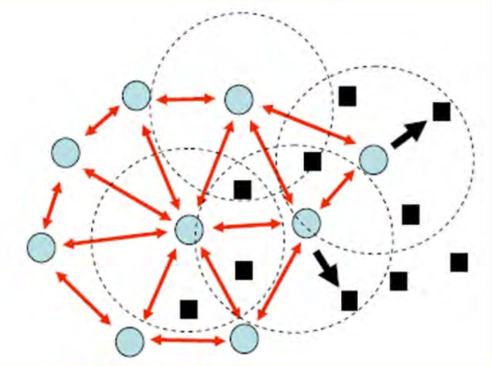

Figure 10: Supplying the swarm with deeply embedded global awareness.

```
hop_nodes(C1, C2, .... Cm);
nodal(D1 = distance;, Targets); frontal(Exchange);
repeat(
extend(Targets) = search(D1);
select_move_destroy_remove(Targets);
stay(Exchange = Targets; hop(neighbors);
merge(Tagets, Exchange));
sleep(delay))
```

Problem: destroyed targets should not be accounted visible any more.

With superior, migrating, global awareness and consciousness

We may modify and extend the previous SGL swarm scenario by adding a higher-level awareness operating autonomously and independently over the basic swarm organization, see figure 11a. We can also organize the focus of such superior consciousness as constantly migrating between the chasers, as in figure 11b. It is supposed that this superior awareness-consciousness initially applied in any swam node, is capable to contact directly all swarm nodes in parallel and collect all they see, and then directly distribute toall nodes this global vision. In case of problems with direct communication between any nodes, this access from a node to all other nodes can be easily carried out by using a dynamic spanning tree covering the whole swarm. This will work by available communications between neighboring nodes, say, when the swarm covers a large area or operates in complex geographical or weather conditions.

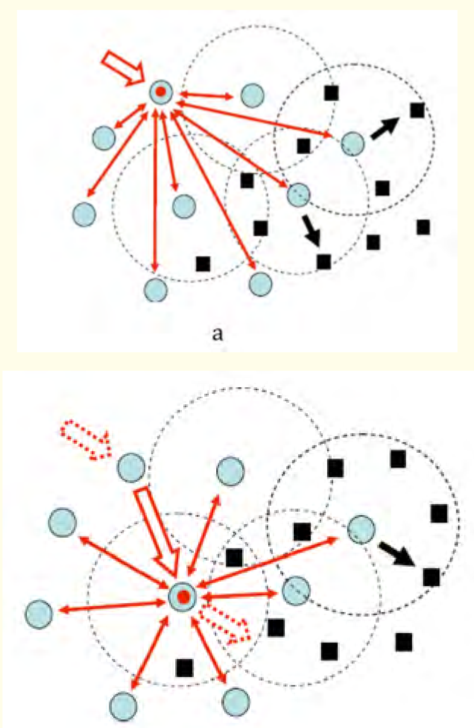

Figure 11: Supplying the swarm with higher-level migrating global awareness

```
nodal(D1 = distance, Targets); frontal(Global);
parallel(
(hop_nodes(all);
repeat(
extend(Targets) = search(D1);
select_move_destroy_remove(Targets);
sleep(delay))),
(hop_node(any);
repeat(
Global = merge(hop_nodes(all); Targets);
stay(hop_nodes(all); merge(Targets, Global));
move(any_neighbor))))
```

The overall consciousness of the swarm can always remain operational regardless of the varying number of interacting units in it, up to a single unit of its possible final reduction.

5 SGL and some mental concepts

The SG paradigm discussed can also be potentially linked to much higher and more general concepts (like [37-49]) than those traditionally used for the system descriptions, with some of them following. Understanding is a psychological process related to an abstract or physical object, such as a person, situation, or message whereby one is able to use concepts to model that object. Understanding is a relation between the knower and an object of understanding [37]. Also, understanding the problem is often the main part of its solution [38,39]. Perception is the organization, identification, and interpretation of sensory information in order to represent and understand the presented information or environment [40]. Self- Awareness and Mental Perception go even higher [41].

At the highest level is the concept of Consciousness [42], with many theories and fantasies of what it actually means, can even exist outside the head [43] or pervade the Universe [44], also relation of consciousness to space [45,46]. The soul [47] within many religious, philosophical, and mythological traditions is the incorporeal essence of a living being. It is to comprise the mental abilitiesof a living being: reason, character, feeling, consciousness, memory, perception, thinking, etc. Depending on the philosophical systems, a soul can be either mortal or immortal [47], and such guesses as its possible separation from body [48], when does it enter the human body, or where does it reside [49] are even fantasized too.

6 Conclusion

The paper demonstrated some higher-level psychological, philosophical and mental capabilities of the developed Spatial Grasp model and its basic Spatial Grasp Language, which can be practically used for organization of highly intelligent distributed and holistic systems, and in very different areas, with many researched applications in this area have also been described in [2-11,17,18,33-36]. We are currently analysing potential applicability of SGT and SGL for advanced NASA JPL projects oriented on investigation of other planets, including those oriented on collective behaviour of multiple robotic units exploring completely new and harsh environments [50].

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