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Original Research

Diagrammatics: Design Intelligence System, Methodology, and Strategy in Design Research and Science

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Abstract: The term *Design Intelligence System, Methodology, and Strategy* indicates a new digital modality of architecturally constructed and visualized diagrammatic research framework and environment. Aiming to facilitate, articulate, and support any kind of documentary, scientific, and creative investigative practice with large amounts of data in a formalized way, *DI* system, methodology, and strategy have been proposed for consideration to be included into the fields of Design Research and Design Science. It has been argued that they can offer a specific response to various research requirements and make a contribution at the level of methodology, instrumentation, and research strategy. Beside the control and guidance of data-operations in line with research subjects and questions, the system preserves design research procedures and dynamics of problem-solving and decision-making as formal inscription, or information-architecture, enabling one to visualize maps and lines of inference and connectivity between different information and arguments, and to acknowledge main issues in delivering a proof and carrying out valid reasoning. Regarding the fact that, alongside extensive use as a means of artistic exploration, this kind of digital framework, formalization, and system has not been substantially questioned as a means of reliable and functional scientific research in the targeted Design Research and Design Science fields, the paper will address these issues through comments on the system's attributes, arguments, relevance, and contributions, and analysis of the performed test-studies, their development stages, and the system's determinants, which have led to its final eleven criteria-form. The field of Diagrammatics has been proposed as a broader context due to the Design Intelligence System's central diagrammatic properties and modes of operation.

Keywords: *"Design Intelligence System, Strategy and Methodology," Design Research, Design Science, Datascapes, Information-Architecture, Architectural Design, Diagrammatics, Information Visualization, Digital Research Tools*

Introduction: Main Concepts and Research Subject

Design Intelligence

Design intelligence designation has been used interchangeably. It gets related to different frameworks, such as methodological, strategic, or attributive and descriptive, depending on the plane of its application. The system has been called *design intelligence system* or structure; its strategic employment and modality have been denoted by *design intelligence strategy*, and methodology as *design intelligence methodology*. When used as a set of investigative methods in problem-solving or -analysis, delivering of a scientific proof, and provision of relevant evidence,

it is defined as *design intelligence methodology*. When related to direct interventions and action plans as a set of contextual procedures performed to obtain evidence in concrete situations from meta-perspective alongside problem-solving and analysis, its mode is identified as *design intelligence strategy*. In this case its operations do not happen separately from the presumed context of application but directly interfere in the identified problem or a set of contextual parameters, thus influencing present situation in a desired manner. The third basic mode implies the explanation of properties and principles that define *design intelligence framework and system of research and action*. Within this register, each characteristic or criterion represents a systemic attribute while their grouped form, by directing its mode of operation, qualify certain research systems to be classified as a *design intelligence system* (DIS). In this regard, eleven features can be distinguished as satisfying the requirements of each framework.[1] They include the following: (1) meta-level processing and metacognitive strategy, (2) diagrammatic thinking strategy, (3) timeline and palimpsest strategies, (4) topological thinking and representation, (5) relational networking strategy, (6) spatial thinking: data-scaping and mapping (data-architecture strategy), (7) memory palace strategy (digital interpretation), (8) quantum logic decidability, (9) dynamic complexity and adaptability strategies, (10) data forensics (information reliability), and (11) creative interactive thinking. With reference to the main DIS representative project (Figures 1–6), the stated features will be explained regarding their function and application in the following sections.

Considering the theoretical and conceptual foundations and parallels to the development of the concept of *intelligence*, including fields of architecture (Speaks 2002, 2006, 2010 [in Sykes 2010], 2012a, 2012b; Saunders 2007; Corner 2007; Allen, Foster and Frampton 2007; Van Schaik 2008; Mallgrave 2010; Hall and Citrenbaum 2010; Light 2015; Wright Steenson 2017), cognitive sciences and philosophy (Gardner 1983, 1993, 2007; Messik 1992; Clark and Chalmers 1998; Clark 2008; Menary 2010), neurosciences (Purves et al. 2001, 2018; Dudai 2004; Jäncke 2009a, 2009b; Rubinov and Sporns 2010; Fornito et al. 2011; Sporns 2013; Richiardi et al. 2015; Goldman 2015), artificial intelligence and design of artificial cognitive and neural systems and networks (Galloway 2004; Negnevitsky [2002] 2005; Bostrom 2014), or the sciences and systems of support in decision-making (Warner 2002; Wheaton and Beerbower 2006; Steele 2010; Hall and Citrenbaum 2010; Dokman 2019), and the way all these traditions have been synthesized, transformed, and adapted to be applied to the explained *design intelligence system and research structure* (Ćirić 2016a, 2017a, 2019b, 2020), more details can be found in the supplementary material linked at the end of this article (Discussions 1 and 2).

[1] Differentiation between the frameworks is usually achieved through semantic refinement of each concept contained in the criteria, their names and definitions (such as modal change—definition as an attribute [a word that indicates certain property], a verb or an operation [a word that implies action and procedure], or a noun), while additional connotations are derived from the context and application framework, being explained and specified through precise instructions.

Diagrammatics

Diagrammatics is a term coined and adopted to cover a broad array of skills, approaches, techniques, methods, strategies, thinking and research systems, and scientific areas that investigate or deploy *diagramming*—intellectually guided use of graphic representational systems, or graphic representations, as means and direct inscriptions of intellectual performance or reasoning. In a more specified sense, it implies the use of diagrams and diagrammatic systems in thinking processes, conceptualizations, representation, and translations from abstract ideas to realization, giving instructions for concrete action and production. Alongside reasoning through diagrammatic visual syntaxes, the field of *diagrammatics* also includes different diagrammatic tools and forms of explanation that support knowledge and information acquisition, production, analysis and transmission, development of critical thinking, and action in practical situations (Ćirić 2018). In addition to other ways of operationalizing diagrams, drawings and graphic media in general, similar is reflected in the notion that *diagrammatics* "identifies a cognitive inquiry into the use of graphic figures in the mediation of meaning" (Knoespel 2001, 149), or inquiry into the diagrams' expression of cognitive agency and diagrams as (*writing/reading*) technologies through which we remember and think (Knoespel 2001), as well as discover (Knoespel 2001) and invent. The latter will be separately addressed in one of the following sections in line with the intent to put forward the proposed system as an interactive, dynamic cognitive device, shaped and constructed (*written*) by its users and interpreters.

Diagrammatic Attributes

The *Design Intelligence Investigative System* (Figure 1) has been founded primarily on diagrammatic properties (diagrammatic methods of data/information processing, management, logical networking, and representation) and demonstrates refined articulation of complex dynamic data/information systems and their multiple variable entities. It has been devised to perform analysis, data articulation, and problem-solving by means of specific diagrammatic (visual) inference and language. Thus, its phases or resulting structure (due to the fact that this system is in constant "becoming" [Deleuze and Guattari 1987; Stagoll 2005], or construction through information updates) have been assigned the status of a diagram—of an active principle, manner or register of data, information and knowledge acquisition, production, evaluation and (re)structuring. Based on these premises, it has been interpreted within the diagrammatic framework and the newly proposed field of *diagrammatics* as its broader scientific, theoretical, and methodological context and perspective.

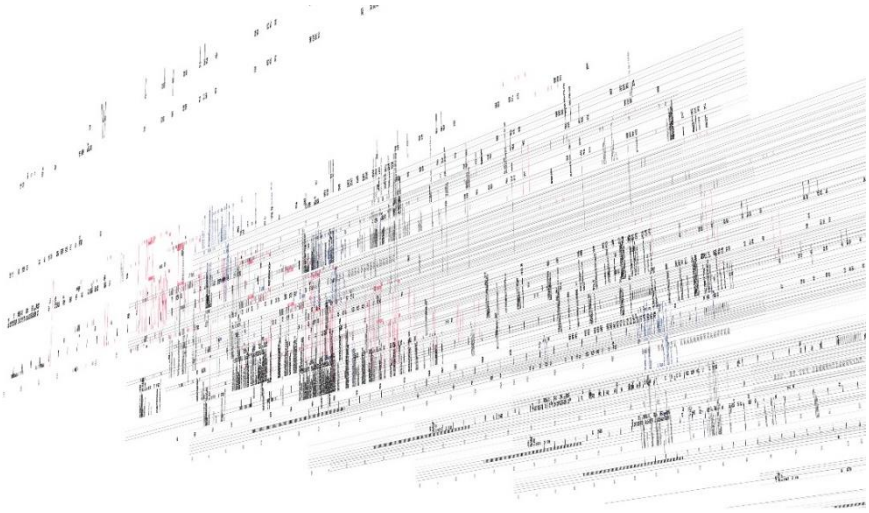

Figure 1: 3d (spatial) view of design intelligence system, its data-field or datascape (elements of semantic content), spatial organization, and form (architecture)
Source: © Ćirić, D., 2016-2017

The field of *diagrammatics*, in this regard, has been substantial for two *design intelligence* (DI) levels,[2] later on transposed to the first two properties and strategies of the DI system and strategic action research mode. The first one refers to the internal relational logic that becomes established during the system's performance by following its formal and syntactic rules in line with the research objectives. Such diagrammatic property can be interpreted as a kind of digital thinking regime that converges the automated machine procedures

[2] Two levels of application or manifestation of diagrammatic properties and performances have been distinguished according to basic features and definitions of the concept of the *diagram*. They have been determined in line with the word's twofold meaning following the etymology of its main constitutive part *dia*. The first meaning refers to relational principle (δία-, with lowercase δ) or something contained in or that cuts through the matter of inquiry (an all-pervading immanent "agent of an ongoing creation" (Vellodi 2014). In such form, *dia*/*diagram* indicates the property of mediation and variation, a property or an instrument and action of relational networking or connectivity, the property of being able to perform the transversal and transformative movement through the subject matter and the world-forms that it simultaneously structures, generates, records, and explains, signifying also the act and principle of their division or differentiation. The second meaning stands for the meta-perspective from where it becomes possible to encompas, comprehend, or direct the relations within the subject matter as a whole and construct the *world*, also equated to the principle and law that orders it (Δία-, with capital Δ, in certain sources related to God – namely Zeus or Jupiter [Plato 1921]). In contemporary scientific interpretation, the latter can be related to metacognition or metacognitive operations and capabilities.
The interchangeable meaning of the first part of the word *diagram* (δία/Δία) and performance or state it implies have been paired with and specified through the meaning of the word *γράμμα*—i.e., relational principles and the semantic content signified by prefix *dia* become visible or conveyed *through*/*by means* of graphic inscription or representation. For more details about the sources used to support definitions and interpretations of the term *diagram*, see the Appendix.

(algorithmic rules) and human input and logic of thinking in an open design protocol. This relational activity inscribes *connectivity patterns* (Müller 2014; Ćirić 2016a, 2017a), which are best perceived at the second level of analysis (metalevel), shaped and extended by the system's property of cross-disciplinary metacognitive networking, at the same time part of the second diagrammatic feature. This feature has been paired with the system's external view or meta-view on its performance and construction of valid logical arguments within. It stands for both the system's metalogic and metalevel defined by analogy to the higher-level cognitive operations and performances it has incorporated and adapted to specific research program.

Diagrammatic Proof and Representation

Intellectually guided graphic communication and construction of spatial formal systems in order to convey ideas or arguments belong to the area of representation of diagrammatic structures and their operations. The transfer of ideas through visual elements is usually carefully designed in order to achieve a desired communicative and practical aims depending on the field of application. It makes an important part of the system's solution, directing definition of basic properties of the diagrammatic data-environment's structural elements[3] and also the ways in which all entities and dynamic operations are going to be perceived and inferred. The visual and graphic solution, by proposing the model of thought-image relation (Tversky 1999, 2001, 2005, 2008, 2010), becomes an equivalent of the abstract thinking and the frame it follows (logical inference, valid reasoning, scientific proving, creative thinking, thought experiments, etc.). The "hidden" logic of thinking processes that remains mostly invisible or has to be specifically decoded from the existing records and material objects as their final states, is specially targeted, represented or inferred through the chosen visual language.

The guidance of thought processes through syntactic rules and semantic elements of the *design intelligence system* presents one of the most important objectives of the project. The design research process and its system of representation have to respond to several requirements—they have to be valid and accurate (Moktefi and Shin 2013), made clear and easy to decode considering the used or designed formal and visual system, well-structured, and enabled to function in an interactive mode. Therefore, at one level, they imply the use of specific methodology of dealing with evidence aimed at delivery of proof or performance of valid reasoning (Moktefi and Shin 2013) and conveyance of the strategic inference and decision-making for concrete actions. On another level, these features have to be unambiguously diagrammatically and visually transmitted or represented in order to provide clear communication of arguments and proposed claims.

[3] Design defines the system's formal language—points (point cloud) and their distribution; construction and connectivity lines; the rules of organization (syntactic rules) and formal distribution; the use of semantic or textual elements; etc.

In the case of diagrammatic delivery of proof or diagrammatic representation of reasoning, the main difference in comparison to other investigative procedures that evolve either without previously formed code of conduct or use of visual language, resides in full awareness and precise construction of each aspect and element of the process and its representational system. Regarding the *design intelligence system*'s performance and design, it has been claimed and confirmed that deliverance of proof by its means is attainable and it can be highly facilitated through careful planning of all its entities, along with graphic or diagrammatic guidance of the investigative process. Conducted research studies (the plan and the prototype of digital research system and platform, alongside theoretical studies) have demonstrated this performance. They have supported the claim that diagrammatic (visual) inference and system of proof could be equally treated as the propositional (linguistic) or symbolic ones considering the field of scientific research (Kulpa 1994, 77-78; Moktefi and Shin 2013; Shin 1994 in Moktefi 2017, 81; Moktefi 2017; Sloman 2002; Lindsay 2002). The latter has been one of the most important arguments of the study, and particularly subjected to experimentation. Its confirmation and proper formalization in terms of a system, methodology and strategy have been the main focus and targets of *Design Intelligence* project realization.

Dynamic Attribute

The initial diagrammatic character of the *design intelligence system*, *strategy* and *methodology* enables another important performative asset regarding the code of research conduct. Governing its mode of operation that has to be transformative and flexible, this property is directly related to dynamics that the system should have the capabilities to articulate. Necessary for the second- and higher-order performances enabled through feedback loops (the higher cognitive performances), interactivity, and variations within the system, the *dynamic attribute* has been included in the main set of the system's performative demands. This feature has evolved into several properties or strategies which deal with variable entities and complexity in scientific operations and research. They include temporal change and movement, update and checking of data-entities, interactivity, dynamics of data networking (formation of connectivity patterns), and decidability within the process of inference.

Design Attribute

The next attribute puts *designerly properties* in function of the *intelligence research structure*. Starting with an explanation of the difference between the *model* and *design*, together with the problem-solving approaches based on their application (Jonas 2007), construction of the *design intelligence research apparatus and instrument* has been designated by the latter. Differing from the problem-solving *by modelling* (which indicates emulation of the existing conditions and arrival at the solution through their analysis, verification, and usually fragmented or gradual transformation), the problem-solving approach *by design* implies construction of

completely new conditions or situations related to the investigated issues. While doing so, it assumes that the convergence of these new conditions will bring a solution to the initial problem by enforcing the problem to adapt, comply with, and change according to the new environmental parameters. Since *design intelligence strategic frame* has implied this kind of action, its research structure has been considered *by design*, aiming to secure this approach in its further operation, too. This has been ensured by enabling the sets of parameters and formal rules to be sufficiently open for the researchers' interventions towards proper and valid inference paths as well as towards the projected solution or a kind of hypothesis that could be further developed and shaped in such framework. Thus, a *design attribute* has found its place even in the system's denomination. The term *design* in *Design Intelligence* (system, methodology or strategy) implies the ability to construct new situations and research frameworks out of the basic settings and the least number of predefined rules. The approach, therefore, enables the subjective perspective and certain features to guide and transform the research process alongside standard investigative procedures, including improvements and changes of the system's structure in regard to the specificities of each investigative process and research subjects. It has been presumed that different individual and group research efforts can uncover certain setbacks of the existing tools, improve their performance, or invest in their advancement. Accordingly, such activities (creative interventions and *designs*) have been allowed within the system; they have been controlled by the main constitutive formal and syntactic criteria of the research framework and structure but with certain flexibilities. The transformations might take place due to particular skills and abilities of individuals—their extra-knowledge that might be included in epistemic, performative, and technical improvements and interpretations (analogy to Shin 2003) based on receptivity of the "multiple reading method" (Shin 2003, 2) in such framework.

Memory Attribute

The *Design Intelligence Structure* has been built so as to enable diagrammatic visual inference, guidance through thinking and research process, facilitation of understanding, and delivery of relevant arguments. All these performances have been dependent on database capacities—collected evidence, their critical analysis and manipulation, including the way they have been preserved and retrieved (*archived* and *diagrammed*). In a dynamic setting, storing and processing are inseparable and as such they represent another important aspect of the system. Hence, from the perspective of this property, the proposed *intelligence structure* has been designated by a notion of the digital cognitive or memory instrument and extension, as well. The concept has been used interchangeably with several more such as *digital connectome* (Ćirić 2018a) and *digital memory palace* and *architecture* (Ćirić 2016a, 2017a). Based on the spatial integration of their formal syntactic and semantic attributes and elements (Lima 2011, 2014, 2017; Meirelles 2013) toward a certain form of *data-architecture* or *information-architecture*,

they have both been related to design action and procedure of digital *memory-scaping* (Ćirić 2018a)—an action and procedure of spatial organization and control of the constitutive units of memory, and construction of the complete archival or diagrammatic system. The first concept (*digital connectome*) implies important references to neuroprocessing and its interpretation by information sciences—the representation of the human connectome through graph and network theories and models (Sporns, Chialvo, Kaiser, and Hilgetag 2004; Sporns, Tononi, and Kötter 2005; Bullmore et. al. 2009; Bassett and Gazzaniga 2011; Sporns 2011a, 2011b; reviewed also in Ćirić 2017a, 2018a). The second one (*digital memory palace*) implies connections to historical examples of architectural mnemonic or mnemotechnical devices (Yates 1966; Dominic and Hall 2010; Ćirić 2016a, 2017a)—the examples that have established or used the method of information storing and ordering spatially (and architecturally) having as an objective the memory training and enhancement, and communication of different content through such spatial systems. These data- and information-architectures include important ambitions towards the application of machine intelligence, too (Negnevitsky [2002] 2005; Bostrom 2014). They indicate human-machine contingency and convergence while also referring to arguments of the *extended mind theory* (Clark and Chalmers 1998; Clark 2008; Menary 2010).

As it can be seen, all these concepts imply and converge important references—the rules of memory in human cognitive systems (short-term and long-term consolidation and restructuring of information [Dudai 2004], alongside the property of plasticity [Jäncke 2009a, 2009b; Goldman 2015]) to which the critical questions about their machinic counterparts and ICT and ICS interpretations have been added. The latter has particularly emphasized the theoretical and practical turn within the field of data systems design and programming – the move from the *categorizations* or the *logic of store*, on the one side, towards the *diagramming* or the *logic of search* of big-data systems on the other (Carpo 2017; Ćirić 2018a).

Spatial/Architectural Attribute

By externalizing and representing stated cognitive functions, processing, and archiving, a demand on memory is reduced and information processing facilitated (Tversky 2001). Architecture and space possess capacities to make this translation more comprehensible and apply it within their own disciplinary objectives,[4] but they can also entrust their medium (space and architecture) to various disciplinary contexts and operations, including research/science, information analysis and processing, to "advance communication and memory of different content" (Tversky 2001, 109-110). This leads us to specific

[4] The notion made by Tversky that supports successfulness of memory palaces/architectures regarding memory demands and this argument in particular, can also be added: "Spatially organized information can be accessed, integrated, and operated on quickly and easily, especially when the spatial organization reflects conceptual organization" (Tversky 2001, 86).

spatial/architectural attribute of the *Design Intelligence System* as one of its most conspicuous constitutive features, as well as the feature that has, in concert with (diagrammatic) memory attribute, determined the form of digital memory palace.

Overview: Case Studies and the Research Practice-Based Design Knowledge

The relationship between *design intelligence* (new design research mode and practice capable of delivering a diagrammatic proof) and *diagrammatics* (on the one hand indicating DI's broader framework and on the other its inherent property, performance or strategic criterion) has been put to analysis, tested, and applied through several studies (Ćirić 2016a, 2016b, 2017a, 2019). During these phases, the investigative process has been led through the proposed and prototyped *design intelligence framework* with the aim to affirm its credibility and merit approval as a legitimate scientific research model (or a design). The claim has been demonstrated through its performance while the ways by which it has facilitated research process and problem-solving have been critically observed and explained. The possibility of diagrammatic deliverance of a scientific proof through *design intelligence system and methodology* could have been confirmed, providing evidence and arguments through results of the research processes. Perhaps only one feature, if compared to linguistic explanations, could have been put upfront as potentially undermining the precedence of such an approach. DI system's language might have appeared more demanding to decode due to its compressed complexity, thus introducing possible ambiguities in understanding. Such obstacles, however, could have been easily overcome through refinements of visual syntax and its rules, along with the inclusion of certain instructions as it has usually been the case with these kinds of systems (e.g., annotations [Thudt et al. 2017] or other types of explanations). In this regard, the formal rules have all been properly defined and their increase during the process contributed to the necessary improvements.

The evidence of diagrammatic inference has existed all throughout history. Their collection, analysis, and critical selection for construction of the major planes of reference have been one of the author's aims, as well. While disciplines such as basic sciences (natural philosophy, physics, mathematics, etc.) have used standard graphic forms, architecture represents a specific research area. In architectural cases, a proof might take different formats - beside the graphic and visual material, the category of the built objects comprises of important forms of expression to be used as arguments themselves or sources of their soundness. Spatial geometric, structural or design laws, theories, and intentions, as well as design processes' stages and their temporal dynamics, can be said to have been stored and conserved in concrete matter. Material objects can act as containers of design information or concrete proofs of certain claims and concepts (De Honnecourt 1201–1300; Darcel and Lassus 1858; Lassus et al. 1859; Samaran 1973; Bechmann 1990; Ćirić 2017a). All this evidence and rules of diagrammatic background of certain design action and reflection have been searched

for and collected in previous projects and writings (Ćirić 2016b, 2017a, 2017b). They could have been used in support of the underlying argument - the possibility to conduct complex diagrammatic investigation method and strategy through the constructed DI structure. Hence, theoretical and research parts of all inquiries have played a significant role in directing and shaping the proposed and prototyped research structure.

In reference to the results and success of the performed studies, the author has also completely disclosed her awareness of the need for several refinements at certain levels. The stage presented in this paper promotes the system's formalization and performance so that further improvements can take place and be properly directed. The *design intelligence system and structure* have been aimed at authorization and approval of credibility and validity in terms of their scientific investigation model and design, standing for one of the contemporary modes of diagrammatic deliverance of proof, in support of all the previous claims of this kind (Kulpa 1994; Shin 1994 in Moktefi 2017; Moktefi 2017; Sloman 2002; Lindsay 2002). Its final stage, still in the phase of a prototype and technical solution proposal (Ćirić 2020), would be the conversion to dynamic or real interactive digital mode. The properties have been defined both in terms of relevance and operation (algorithmically), which makes them directly convertible to such digitized framework.

Relevance

The relevance of the DI research and methodological framework has been reflected in strong demand to deal with recent problem of data and information ubiquity and amount produced through mass-digitalization and raised accessibility to different kinds of research material and documentation. It has been argued that their reliability, articulation, evaluation, and selection according to specific and objective criteria in scientific research could be dealt with in a more coherent way, according to proper predetermined methodology. The process of discovery and investigation could be guided and alleviated by means of the proposed *digital intelligence structure*, while each researcher could also form and create his/her own data-architecture to record (memorize), propose connectivities, and perform updates and restructuring of the used data according to the research needs and requirements.

The lack of proper references in the previous and existing research models,[5] as well as the radical shift in technologies that made some of the existing research methods and approaches obsolete or inapplicable under new conditions, made the invention of the most suitable data processing investigative system in scientific and creative practices a primary task. The problem of knowledge accumulation and augmentation and the need of correlative, comparative thinking while including vast historical funds of differently discursively framed documents, made academic research requirements and professional responsibilities more

[5] The majority of the learning and search algorithms are not subjected to scientific requirements and methodologies, nor are they under a demand to deliver evidence or a proof, or be guided in such a way.

complex. The change of criteria, new research fields, and big data logic of information organization (Anderson 2008; Gooding, Terras, and Warwick 2013; Mayer-Schönberger and Cukier 2013; Gandomi and Haider 2015; Carpo 2017) influenced transformations in available research systems and posed demands for their refinement and innovation. Proposed dynamic cross-disciplinary and metacognitive performance of a *design intelligence platform* (Figures 2 and 3) has been presumed to clarify this oversaturated and de-structured data-context of each individual research framework and process, while also generating motives for innovation based on its interactive relational properties and features of an open-system (the high degree of contingency in cybernetic terms).

Concerning the scientific context of the research and the noted claims of relevance, the following paragraphs will aim to explain the main properties and operation of the proposed *design intelligence system, methodology, and strategy* to present results of the performed studies, and to propose the platform's use, improvements and further development. It is expected that this research mode and line of investigation could be scientifically grounded within the field of design research science and methodology, as a solid basis for future scientific and artistic research, innovation, and development.

Hypothesis

The central hypothesis claims that the scientific proof can be delivered diagrammatically (Kulpa 1994; Shin 1994 in Moktefi 2017; Moktefi 2017; Sloman 2002; Lindsay 2002), that it can take a notion and a form of a *diagram* as a cognitive model (Foucault [1969] 2002; Deleuze and Guattari 1987; Blackwell and Engelhardt 2002) and therefore a research model (Ćirić 2016a; 2017a) or design instrument (Allen 2009; Somol 1998, 1999; Lootsma 2002; Vidler 2000,2010; Garcia 2010; Ćirić 2014, 2016b, 2017a, 2017b; Anderson, Mayer, and Olivier 2002; Stjernfelt 2007; Pombo and Gerner 2010; Tversky 2001) not being limited only to discovery and heuristic setting (Moktefi 2017). In these cases, the semantic elements have been replaced or supplemented with graphic and visual characters or elements. The succession of premises, arguments and conclusions could be followed by their means, secured by the chosen and constructed formal language and rules of possible configurations. These claims have been tested on design intelligence research and the representational structure and system designed by the author of this paper. Within their framework, several key parameters have been defined in order to support and reinforce the scientific status of a diagram and make the system operate towards the results that have been argued and expected. The eleven properties of the *design intelligence system* have been argued to secure its position of investigative instrument and framework and the ability to deliver the scientific proof. They have composed and specified its graphic formal language and operations.

The main criteria and conditions of the scientific research methodologies and design research methodologies have been analyzed, transposed, and integrated into the system's

performance (its syntactic rules and structure) and finally its own methodology. This has led to the proposal of the first subhypothesis, which presumes a *design intelligence methodology* as a system that can articulate the investigative processes and theoretical assumptions towards their resolution, provision of valid arguments, and operative research results. The second subhypothesis presents the *design intelligence* strategic mode. Within this register, a *design intelligence strategy* has been proposed as a frame of actions to be performed within the research process if aiming to intervene into the research situation in order to obtain reliable evidence and successfully articulate the problem of research material complexity and its various degree of relevance. Both modes rely on the ability to encompass the widest picture and domain of the research problem, plan, objectives, and involved research areas from a meta-position.

Concerning the formal framework, architectural spatial approach has been argued to be of a key importance for data-structure's distribution and operations that could have been applied here. Already relying on diagrammatic and temporal structures and properties for the system's concept, the spatial feature has added to their convergence another value regarding both processing and organization (the performance aspect), and communication (the representational aspect) of the research content and research process. Performance and visual communication have been conceived spatially. Having as the primary subject various spatial organizations, their formalization, relational characteristics and dynamic development, architectural perspective and approach to problems could have enriched the domain of possible systemic solutions, formal syntaxes, elements of formal language, and operations of research platforms. In general, architectural discipline and specific design thinking and logic communicate ideas through graphic means and finally concrete spatial objects or matter. All of them could have been interpreted in terms of the theoretical (spatial) arguments and their proofs—it could have been said that certain hypotheses or claims of the solution of a problem, alongside their lines of testing and development, have been inscribed or contained in architectural material and that, therefore, they have been given a spatial mode. Such interpretation has reinforced the significance of the architectural or spatial methods in reversed situations—their application for control and organization of data-contents and arguments.

Evidence of the design process and the diagrammatic proof in architecture have spatial form and distribution, and it has been assumed that such spatial logic could have been applied to the broader field of diagrammatic proving and performance. One of their specific applications has been on data structures and relations between their formal syntactic and semantic elements in terms of systemic organization. This has been particularly the case with the *design intelligence system*. The spatial thinking skills and sets of parameters have been used in order to define its data and information-architecture. It has been presumed that the resulting structure or *design intelligence* formal system would communicate accurately and efficiently the research process, research content (semantic material and interpretations), and lines of inference and argumentation (valid reasoning and delivery of a proof), if constructed by following all the defined syntactic imperatives and attributes—spatial, diagrammatic, and

temporal being dominant in the visual register, but constituting only a part of the set of eleven criteria.

Even though the term process (as in thinking process or design research process) has been widely used and aimed at formalization, the succession of cognitive performances within the design research and decision-making and their interchangeability in the digital mode have not been the only issue at stake. What has been equally important was their data-environment as a coherent organization and the very subject matter or research content (data, information, and different discursive and nondiscursive forms). They have both considerably influenced the final model and form of the intelligence structure. Since all these entities could have varied or changed dynamically throughout the investigative process, the form of the intelligence structure has been devised as transformative. Constructed to embed dynamic variation, it has been claimed that this structure rather "emerges" in line with the activities performed in real-time and in line with the newly discovered or selected and integrated elements (information) than that it occupies one stable formal condition and remains unchanged.

Methods, Methodology, and the Investigative Process

The aim to build a research model/design that can be used as our parallel artificial, metacognitive, (diagrammatic) data-processing research instrument—a *virtual connectome* (Ćirić 2018a) or an *extended mind* (Clark and Chalmers 1998)—has been tested through several phases. In the course of testing, practice-based experimental research and prototyping have been used as the main research methods alongside standard theoretical analysis and literature review and support. The research has started with the project called *microhistories* (Ćirić 2016a, 2017a), during which the first model and the first round of experiments have been defined and performed following the definition of the set of seven systemic properties (and methods). Further refinements and investigations (Ćirić 2017b, 2018a) brought about its extended version, introducing a set of eight properties (Ćirić 2018a) and additional three properties (Ćirić 2019), which have finally shaped and established the eleven-criteria form (Ćirić 2019) presented by this paper.

Experimental Design Research Methods: Theoretical and Design Prototyping

The initial project has claimed the *design intelligence research platform* to be its main methodological scientific objective. It has devised and posited it as a digital space that would perform as a navigating data-environment for investigation guidance, recording thereby the whole research process and lines of inference. A diagrammatic "weaving"[6] through constructed datascapes (information assigned the spatial formal organization; Figures 1–5) has been performed in order to test and provide scientific arguments. As a result of this phase of the

[6] This term has been used in order to express the character and dynamics of diagrammatic performance—the way connectivities, collection, selection, analysis, and evaluation of the information appear in visual or choreographic interactive terms.

project, the framework for an intelligence platform has been designed, including full data-inscription (insertion of relevant semantic content). Thus, the basic outline of digital structure, being retained to the present moment, has been posited, while the possibility of its further refinement according to new research tasks, the specificities of the research orientation and content, and formal and organizational instructions (Moktefi 2020) have been left open.

The end of this phase has ascertained and demonstrated a design solution and performance instructions of the proposed digital research environment (Figures 1–6). The system possessed specified graphic elements, spatial distribution, and configuration in order to properly visualize and mediate conceptual claims, thus fulfilling the requirement of securing the proper correspondence between the conceptual information and criteria, and the visual attributes (Meirelles 2013). These have solidified its formal characteristics, closely tied to the system's performance attributes or mechanism of operation.

The system's formal and performative objectives have been grounded on the first set of investigative criteria and methods. Each of them had a specific role and reason of application. (1) The first one has introduced the concept of *metacognitive space* (*metacognitive strategy*) and secured its formal solution, presumed to converge different discursive and disciplinary clusters of information and operate across their boundaries. In this regard, the structure has been defined rather as rhizomatic than arborescent, while such hierarchical structures could have been established within this more open higher-order system. The next two—(2) diagrammatic character (*diagrammatic strategies*) and (3) connectivities (*networking strategies*)—served to reveal the existing (but not always visible or easily comprehensible) and newly identified relations, thus contributing to and conveying scientific inference and discovery throughout the investigative process. The nonspatial content has been spatially encoded (4) for purposes of better visual communication and comprehensibility (in which case the *spatial strategy* has been applied). Thus, a kind of *data-architecture* has been constructed, expressing the *topological properties* in certain registers (5), as well as mnemonic attributes. The latter has been related to the property of spatial data-archiving or "memorizing" due to which the *(digital) memory palace strategy* has been proposed (6). The historical (temporal) dynamics have been represented through multiple timelines (7), stacked so as to achieve planned overlapping (as in *palimpsest strategy*) and obtain the best structure for further animation (the representation of the temporal movement in an interactive mode). The semantic information (textual elements) has been organized as a point-cloud that has followed the established spatial configuration—each entity has been tagged to the specific point in space on one of the timelines, or more when the situation required. *Creative design thinking* (8), included without the specific acknowledgment, has also been added due to its importance for the design concept and interpretation of all mentioned and required elements, as well as for interpretation of the attributes defined thus far (Ćirić 2018a). It has been singled out so as to recognize and affirm the individual creative input (representational, constructive and processual) and specificity of each singular scientific research situation and

its objectives. Certain indications towards the dynamic mode have also been provided while they will appear as distinguished criteria in later phases (Ćirić 2018–2020 (unpublished material); Ćirić 2019). At this point, a dynamic attribute has already been contained in the temporal aspect, while its share in assumption of the system's refinement through feedback loops required further definitions. This fact and higher-order updates would demand constant interactive system mode of operation, having traced a direction in which the set of properties would be developed in the upcoming phases.

From this moment, the following studies have been focused on refinement and revision of research operations criteria. In the next few iterations their number has increased in order to better shape dynamic processing, data complexity and reliability, the system's flexibility, and the scientific precision in working with data (Ćirić 2017b, 2018a, 2019). During this period, domain of the structure's content has remained the same (there were no new data inputs), while improvements have been directed towards the instructions for an algorithmic transposition and the design of the system's dynamic interactive mode. For this to be achieved, additional values and criteria have been distinguished and this phase has finally identified the three new systemic properties, while also deriving and refining a creative attribute from the previous set. The properties have included: *dynamic complex systems operational strategies and investigative methods* (8); the *quantum logic decidability* (Bagarello, Haven, and Khrennikov 2017; Broekaert et al. 2017; Jaeger, Khrennikov, and Perinotti 2017a, 2017b; see also Ćirić 2017b) (9); and *data forensics* referring to the problem of reliability of the used information and semantic content of the system (10); the *interactive parameter* has been added to that of *creative thinking*, which has already been indicated in the previous form of the set (11[8]), and they have formed the last convergent attribute. With these final revisions, the section with definitions, formal rules and boundaries, and protocols of the system's performance has been temporarily concluded. Defined properties have been expected to proceed towards the tests of performance and formal soundness in the upcoming prototyping stages (Ćirić 2020).

In summary, it is important to understand the precise role of the mentioned attributes or indicators of the system's performance and formal structure. A defined set of rules implies the formalized ways of reasoning which the system permits or makes possible. It secures the validity of semantic inferences (as in valid reasoning) by syntactic ones at one level (Moktefi and Shin 2013), while applying a profound data and sources assessments, relying on capability of processing their state of transformation at the other. The interactive mode of creative thinking has extended the ways in which the formal elements of the *design intelligence system* can be presumably transformed or manipulated when including specific research content and feedback loops of information check-ups, as well as individual design improvements and changes of the system's initial structure. The latter opened up the space for various transformation rules that could have been allowed within the system (Moktefi and Shin 2013) whether posited by the system itself (predefined) or by an external user and an investigator. With these conclusions, the second phase of theoretical definition and design

of the *intelligence platform* has been closed. The possibility of one of the properties being misleading (for instance only diagrammatic one [Moktefi and Shin 2013] or any other when used isolated and without clarification of the permissible inference rules or rules of performance) has been secured through their proper formal definition and the integrative set of formal rules that enables their mutual corrections (methodological triangulation) and validity of the inference at metalevel (or within the *metascape*). The *design intelligence system* has been shaped to operate as a sound formal and representational system.

The algorithmic transposition of all properties is still in a design process. Relying mostly on the field of logic and information (programming) sciences, digital transposition of the constructed data environment, its animation, and operationalization of the posed objectives require different organization and development, including likewise a further cross-disciplinary extension of the knowledge base and the teamwork. To this end—toward the platform's operative mode and the aim to confirm the *design intelligence research system* as diagrammatic conveyor of the scientific proof and spatial digital environment for guidance and recording of the investigative processes—the described properties have been framed and interpreted in terms of methodology and strategy. They have been listed as follows:

1. Metalevel processing or post-disciplinary metacognitive strategy and method,
2. Diagrammatics and diagrammatic thinking strategy and method,
3. Timeline and palimpsest strategies and methods (enabling macro-historical and micro-historical inference and connectivities),
4. Topological thinking, strategy, or method (whereas certain diagrammatic forms may be analyzed as their topological variety),
5. Relational networking strategy and a research method,
6. Spatial thinking strategy and method of representation: *data-scaping* and mapping in multidimensional virtual environment (data-architecture strategy),
7. Memory palace strategy and method of information archiving (digital interpretation of semantic architecture),
8. Quantum logic decidability strategy and method,
9. Dynamic complexity and adaptability strategies and research methods,
10. Data forensics (the key property for questioning information reliability—an instrument of their validation), and
11. Creative interactive thinking and responsiveness.

In order to confirm itself as a stable framework and mechanism for investigation, and to provide reliable research process and results in line with the posed research subjects and question, the *design intelligence system* has converged the mentioned methods or strategies. In a new arrangement, they have formalized its methodological and strategic *model* and/or *design*, thus making one of its most important contributions.

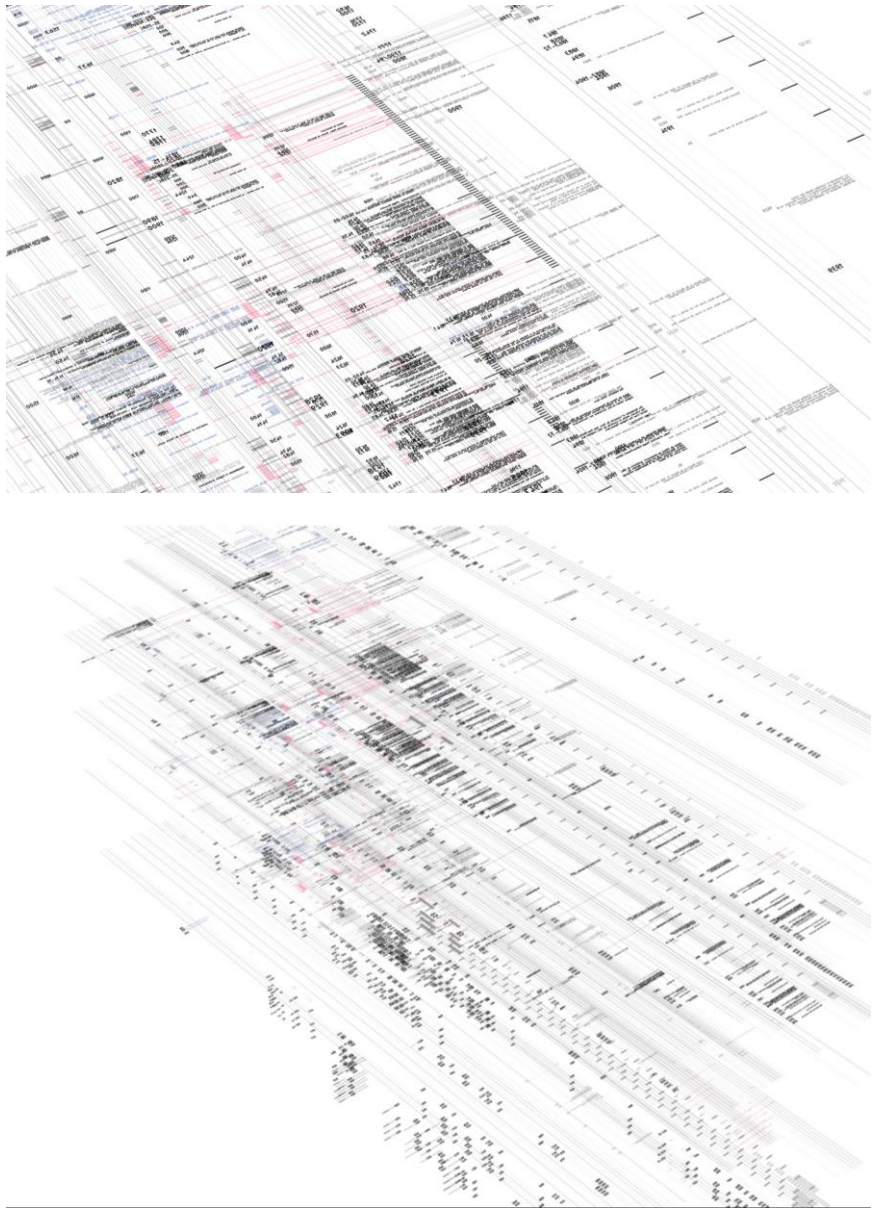

Figure 2: DIS *Metahistorical Datascape* (CAD model): Application of the spatial/architectural, topological and diagrammatic strategies of data organization—spatial organization of the semantic content in parallel timeline planes, each representing one disciplinary field of reference. Each piece of information has been anchored to the specific position regarding temporal dynamics. The form of the *scape* indicates information overlapping and inferences that might be derived from such condition through comparative research method. The resulting *information-architecture* enables de-structuring and restructuring of the existing discursive formations (disciplinary narratives), insertion of new facts, leading to change in the temporary consolidated relations (Figure 3).
Source: © Ćirić, *D., 2016-2017*

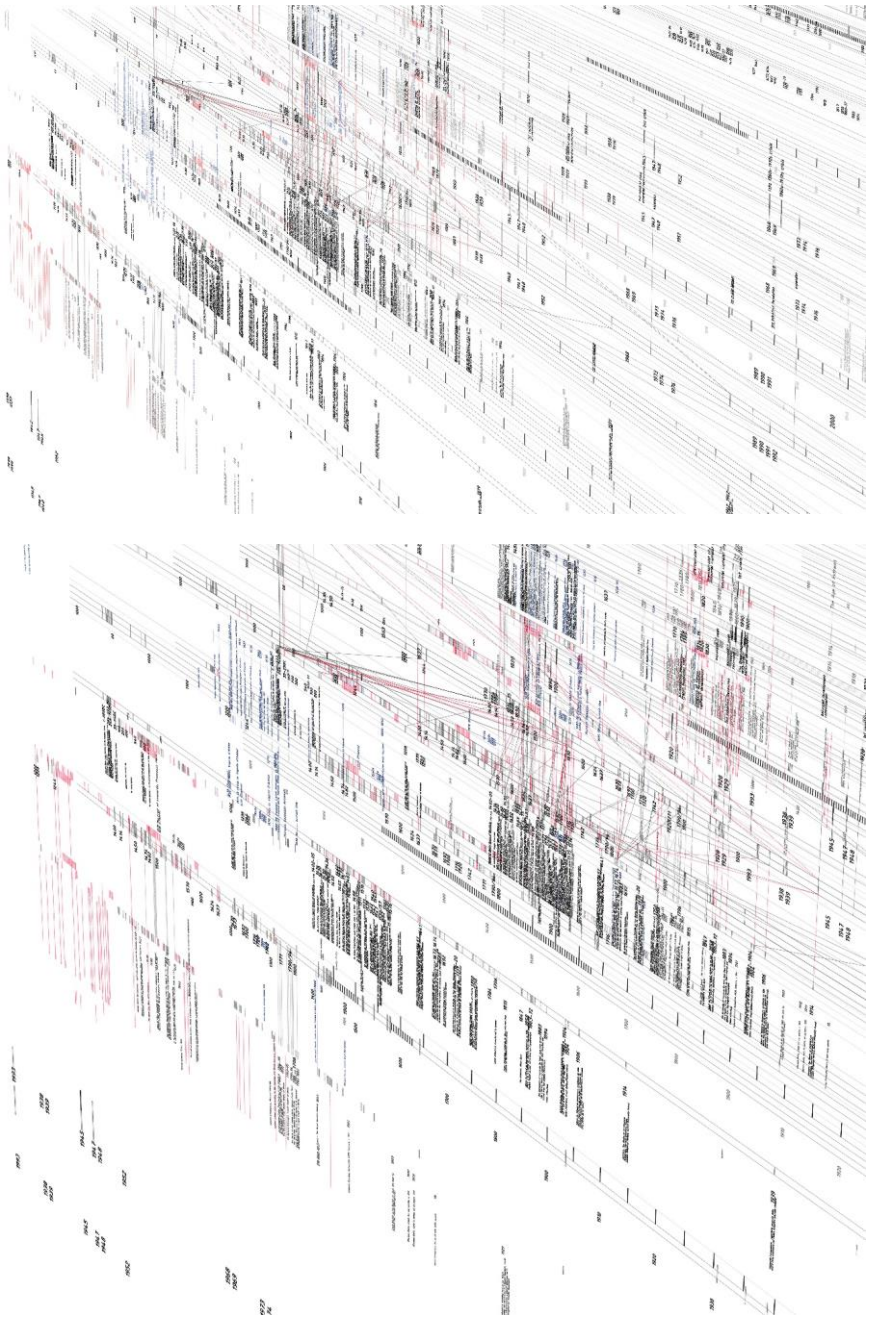

Figure 3: *DIS Metahistorical Datascape - Metalevel Processing*: Application of the metacognitive and diagrammatic networking strategy (construction of connectivities and formation of connectivity patterns), inquiries of the lines of contingency in information, establishment of relationships between elements of the semantic content, resulting in the construction of meaningful syntaxes (valid chains of inference/reasoning and narratives construction).
Source: © Ćirić, D., 2016-2017

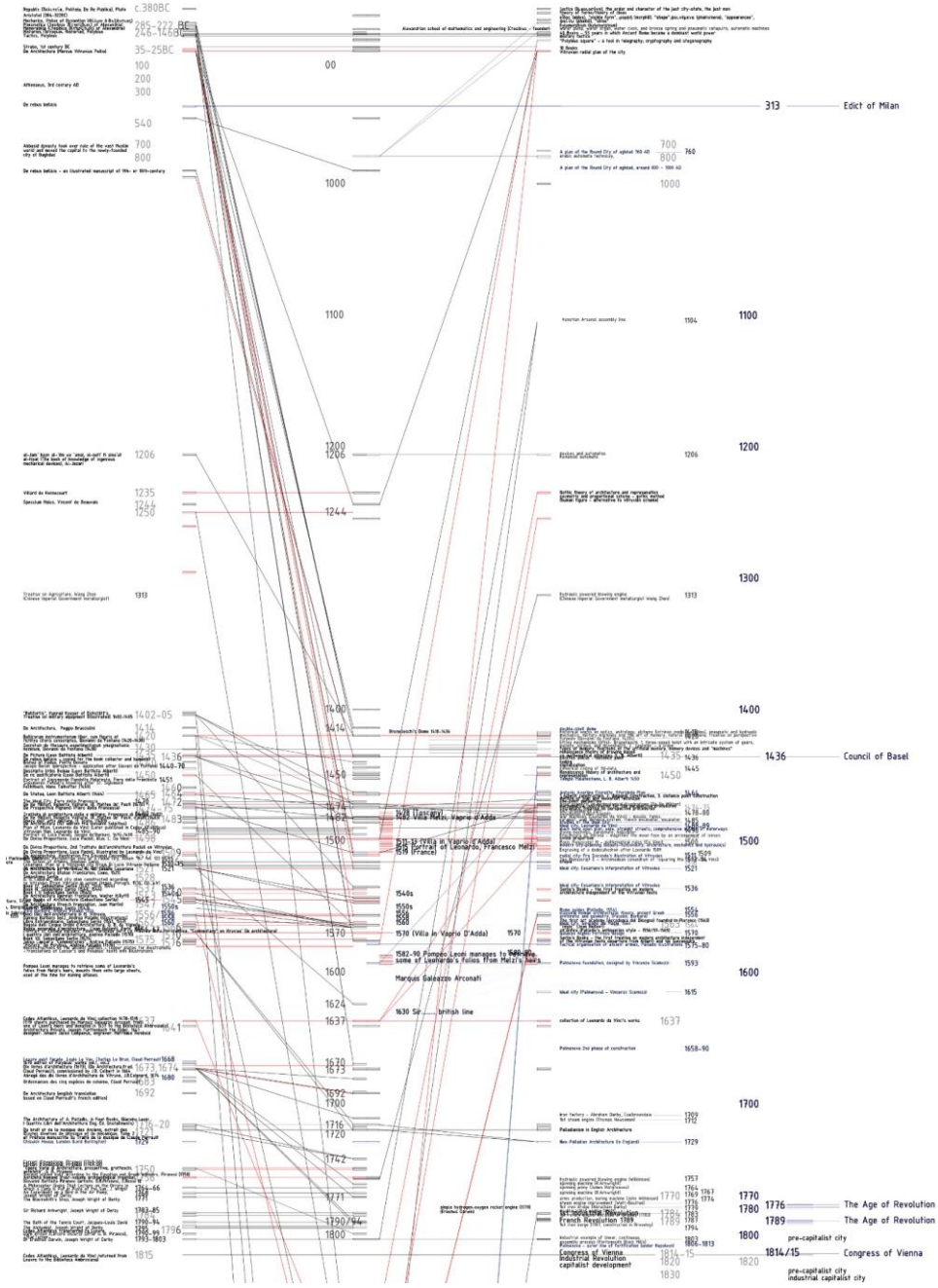

Figure 4: *DIS* Timeline (CAD model) 2d projection, front view: Application of the timeline and palimpsest strategy in data articulation (isolated explanation) —representation that displays overlapping disciplinary planes and convergence of semantic content (juxtaposition).
Source: © Ćirić, D., 2016-2017

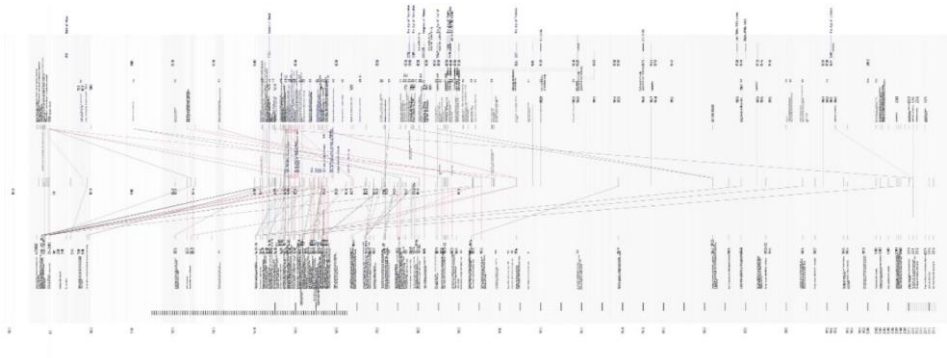

Figure 5: *Design Intelligence System* (CAD model): a. *Timeline Diagram* -2d projection, front preview; and b. *DIS Digital Memory Palace*: Application of the memory palace strategy - 3d preview that reveals spatial structure (*data-architecture*) with disciplinary planes and layers, in which each information has been stored and given specific location within the architectural framework and structure.
Source: © Ćirić, D., 2016-2017

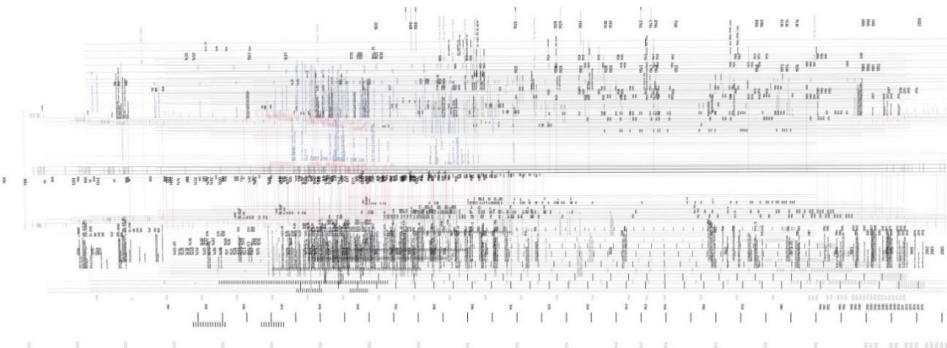

Figure 6: *Design Intelligence System* (CAD model): *Timeline Diagrams*—2d projection, front preview: decomposed design that renders timeline organization of data divided in several planes and lines of temporal development according to the criteria of belonging to certain disciplinary field, and analyzed singularly so as to be merged into the common system with maintenance of specific disciplinary (graphic and semantic) markers. The image shows data arrangements without the connectivities established between them as being rendered in Figure 3, 4, and 5 (the connectivities will undergo certain transformations in the synthetic mode since cross-disciplinary networking will be performed as well).
Source: © Ćirić, D., 2016-2017

Methodology of Visual Diagrammatic Representation

Considering the design interpretation—graphic solution and visual syntax of the DI system (DIS—*design intelligence system*)—its structure has been based on infographic models developed for digital environment, large amount of information and its complexity, with references to representative historical examples (Tufte 1990; Rosenberg and Grafton 2010; Bertin 2011; Lima 2011, 2014, 2017; Meirelles 2013; Henry Riche et al. 2018; Dick 2020; Friendly and Wainer 2021). The main ideas to investigate and compare different disciplinary fields influenced the system's primary spatial division. Each has been represented by a specific

plane, all being given in a parallel configuration (Figures 1 and 2). They have been rendered in a wireframe mode in order to enable overlapping and simultaneous insight in therefore presented content—certain elements and events that have been positioned at the same points in time, have been crossed in regard to different discursive and disciplinary perspectives and discursive frames. Such overview stood for an attribute of a *metacognitive field* or *territory of information* (Figure 2) and its major property of *metacognitive networking* (Figure 3) alongside the ability to operate and rearrange the included elements according to different research questions, hypotheses, investigative methodologies or research systems, and new narratives (Ćirić. 2017a). Referring to Müller (2014), his concepts of the *metacognitive plane* and *connectivity patterns* have been transposed into the spatial- or a field-form, and a point cloud (Ćirić 2016a, 2017a; Figures 1 and 2).

Further, within each plane, textual and graphic materials have been organized linearly in timelines—the "chronological and sequential narratives of relevant historical events" (Meirelles 2013, 87; Figures 4 and 5). Dating from the eighteenth century when they replaced tables and lists (Meirelles 2013; see also Willard 1850; Schulten 2007; Rosenberg and Grafton 2010; Lima 2011), these timelines structures and techniques of representation have been widely used throughout history, while they have been improved and interpreted in digital terms and algorithmic form more recently (Lima 2011; Meirelles 2013). As such, they have been the most conducive to clarity, communication and successfulness of arguments posited by this study (the proof of *microhistorical* development of certain research subjects [Foucault [1969] 2002], or *multiple historical lines of development* and *nonlinear history* [DeLanda [1997] 2000; DeLanda 2002]). Each entity or an event has been assigned a specific place regarding historical (temporal) dynamics, while all its references to preceding and following entities and events have been presented by connection lines (Figures 3 and 4). Events and entities could have generated multiple lines of development, and such refinements, as some studies have suggested (Moktefi 2020), could have been included in the system's final operational mode. Each new multiplication of timelines as well as branching of the directions of development, could be achieved according to new criteria that investigators might insert as a part of their own research objectives and framework.

In an overview, the networking has been achieved within the disciplinary plane of reference, and inter- and cross-disciplinary between the planes. Considering the property of diagrammatic and topological character, the system has aimed to render different relations and logical connection between the included and investigated entities, while the dimensions and ratio in visual representations have been used in various manners. The time division in timelines has been performed by correct ratios and adopted values (uniform scale has been applied for temporal distances or intervals, which have been organized along the graded linear structure, a placeholder for spatial distribution of points in time), while all other graphic elements (the length of connection lines, distances between the disciplinary planes, etc.) did not possess specific numerical indicators or ratio, implying only relational logic (not

necessarily formal) as is usually the case in this type of topological structures. The overlapping or clustering in time has not been particularly emphasized with additional graphic attributes or elements (e.g. sets) but left in a wireframe mode so as to reveal simultaneous existence and development of the analyzed information-entities. In this state, entities could have been easily networked according to primary research questions resulting in different arguments, and they could have also worked as their triggers.

Problems and research questions, or arguments that have been specifically used (parts of semantic content and their chain of contingency and connectivity, therefore the sequences of several judgments), have been visually contrasted to other content, thus marking the whole line of the proof-construction and development. Color has been used to distinguish different classes of events and entities that the investigator has marked as major objectives and thus the structure has been nuanced by one more visual property. Since the planes have already been defined (the field of architecture, arts, history, culture, economy, etc.; Figures 2 and 6), specific theoretical lines and connections through time, whose proof of continuity has been targeted and tracked by the research,[7] were easy to follow even though they shared several planes of reference and were anchored in different points in time on multiple timelines (Figures 3, 4, 6 [decomposed model]). Their active states, reoccurrence (such as book reprints, translations, and critiques, or reactualizations of certain themes and problems) and periods of stillness have also been identified and could have been inferred as narratives having been supported by mentioned graphic solutions. Connection lines have clearly indicated the relations found in sources and literature. By following their movement, one could have constructed linguistic alongside diagrammatic arguments, and delivered a proof or a conclusion in both ways or in convergent manner.

It can be added that mixed diagrammatic-semantic form of inference has been applied as the most convenient category. Since in this case only certain semantic elements (deconstructed from their narratives towards pure dynamic facts) have been used, one cannot claim the standard linguistic argumentation to have been performed. It is rather a situation in which diagrammatic syntax replaces the linguistic formal rules and thus facilitates the process of understanding the reduced semantic content—when combined with semantic elements (information), the graphic structure and visual attributes contribute to the efficiency of inferring and argumentation.

Algorithmic Transposition Methods and Design

The system interactive mode, which still has not been fully applied, needs to be supported by appropriate algorithmic operations in order to animate the existing structure and its

[7] The lines have included the microhistories of (1) diagrammatic thinking and practices, (2) application of geometry, (3) machinic line of thinking, (4) digital thinking, as well as contextually important scientific discoveries, literature and resources, and other entities that could have been linked to subjects of investigation and interest.

elements. The principles, which have been added and defined from the first proposals (Ćirić 2017b, 2019), have been investigating such performance while complementing initial information-architecture. These final interventions and digital transposition to the dynamic state will enable the active form of all attributes, as it has been planned and claimed. The system's openness will leave space for individual creative improvements or transformations according to the research content, questions, and lines of investigation. The design attribute indicates such possibility as well as an option to approach the problem *by design* (Jonas 2007), if using the system's strategic mode.

Present content complexity and visual complexity of the DIS model will be reconsidered regarding additional explanatory and user-oriented (user experience) elements (annotations and instructions, media, visual styles [Thudt et al. 2018]). The imperative of making the presented spatial model more accessible to different interest groups, as regards the stated complexity, will be addressed following the existing literature on data and evidence representation, or visual representation of knowledge and information, and visual communication (Tufte 1990; Blackwell and Engelhardt 2002; Bertin 2011; Lima 2011, 2013, 2017; Meirelles 2013; Henry Riche et al. 2018; Dick 2020; Friendly and Wainer 2021). Some of the strategies represented and argued by these sources will be applied, while also giving space to design originality and recognizability of this particular DIS solution and each individual case of its transformative reassessment and rewriting, when adopted and affirmed as a functional research model. The latter particularly draws attention to the questions of objectivity-subjectivity relation in scientific research framework.

Spatial/Architectural Methods of Information Ordering and Articulation

The system has expressed the architectural appearance and structure. The reason why it has been conceived spatially/architecturally (denoting the references to construction of *memory palaces*, *memory theaters*, and *memory towers*, or generally any form of mnemonic architecture used to enable and illustrate mnemotechnical practices [Dominic and Hall 2010; Penny Small 2010] and trigger the semantic potential of architecture) was the need to find the new solution for storing and relating semantic elements of research content and material. Data, information, concepts, discursive and non-discursive formations relevant for the chosen research subject, area or question, have been studied in a sort of architectural (*designerly*) manner or by its methods (the ways how architects know, think, and act [Cross 2006; 2011]). As a result, the certain spatial form has been defined, further representing the new starting point for progressive development of the DI apparatus. Diversified by topological and dynamic features, the DI system has been planned to be made active and apt to transformation. Thus, a creative design potential regarding its *data-architecture* has been enabled.

Results and Discussions

The contributions of the *design intelligence system* research and project have been achieved in epistemological, methodological and technical registers. The results on the epistemological level refer mostly to research content and inferences that have been recorded during the research process. They include new discoveries, theoretical frameworks and narratives, or epistemological extension of the existing knowledge base. The methodological register covers the proposal of the new DI research framework suggesting integrative use of the stated methods towards planned and desired investigative performance. Finally, the claim of contribution within the technical register implies to the technical solution of the *design intelligence system* in the form of the digital platform, system-architecture, and an algorithm for research operations (Ćirić 2020).

The research system that has been proposed claims several modes of application that could be used aside from the specific situation for which the author has created it, while within this frame of reference it has managed to facilitate the research process and demonstrate several arguments that have been posited both within the methodological and epistemological field of research. Considering this broader contribution for the whole field of *Design Research and Science*, a *Design Intelligence System* has specific relevance. Its definition and proposal to be included into the *Design Research and Science* methodological framework, as well as to be improved and further developed according to action plans of the study, clearly stand out.

Within the discussions, several themes could have been pointed out as either supplementary theoretical arguments and material, or elements that have been principal for the paper's structure, inviting thereby more focused attention to their implementation. The first one covers the sources and references (alongside the critical, scientific, and theoretical frameworks) that have been formative for the *design intelligence* general terminology and definitions, or the way they have been constructed for purposes of the presented project (Discussion 1). The second one reflects upon several major assets of the *design intelligence system framework*—those linked to the main hypothesis on diagrammatic proof and performance, and those explaining the contribution of the architectural approach to research problems (Discussion 2). The other topics that have been left open for further research address: 1) the question of narrativity (Herman, Jahn and Ryan 2005; Puckett 2016; Bal [1985] 2017; Zupan Sosič 2022; Fabri, Sassatelli, and Manghani 2022) of the proposed *design intelligence system and diagrammatic structure*, referring to the shift between narrative and diagrammatic matter as an universal problem (Knoespel on Deleuze 2001), the way diagrammatic structures induce or probe meaning (Knoespel 2001), construct plots for narrative arguments (Knoespel 2001), or render how "meaning becomes before our eyes" (Knoespel 2001, 145); and 2) the question of audience (Drucker et al. 2018) along with engaging and communicative capacities of the proposed structure as related to specific demands of each user, users' choices of the communicative mode, medium and narrative,

different audience demands, as well as possibility of the system to induce and drive cognitive activity and discovery in each user, editor, or observer.

Conclusion

The last section of the paper offers several closing remarks on *design intelligence system, methodology, and strategy* regarding the way they have been suggested for the inclusion into the field of *Design Research and Science*. They refer to contributions and quality which the proposed digital research environment and platform may bring to the scientific community and their different research tasks, requirements, and investigative processes. One of the facts that has become clear through this paper is specificity of disciplinary convergence that has to be performed in order to achieve the objectives of the *design intelligence system* project and technical solution, the convergence that has been presumed to be possibly covered by the field of *diagrammatics*.

In an overview, *Design Intelligence* (DI) is a designerly way of thinking, and the mode of control and articulation of the research process and deployed information, providing support to valid inferring and decision-making. It refers to complex cognitive information structures and systems or specific information-networking logics that lay in the background of each thinking or research process and design intervention. As connectivity structures and active mechanisms, they regulate dynamic information—or data-contexts—in which we operate while dealing with different (spatial, architectural) problems and (design) tasks. They define information and knowledge bases that shape architectural intellectual positions, and precede and direct conceptual decisions and concrete design actions. In the research platform format, DI properties have been digitally transposed and interpreted in terms of a system that could function as an external investigative instrument and tool in research science without a disciplinary closure. A design denomination has been retained to imply the field that has been particularly mobilized for, as well as the approach to construction of the logical and representational solution of the research platform and environment, including specific skills, methods, and creative approaches that this field applies and advocates.

Design Intelligence Strategy is a strategic approach to any kind of research and work with data or information in general that mobilizes design skills and design thinking as its primary assets in problem-solving and fulfilment of research objectives. It may refer to *research by design*,[8] including a profound intellectual plot as a basis of the planned research procedures and actions. *Design Intelligence Methodology*, on the other hand, implies a mode that converts these actions and properties they represent to methods in specific problem-solving and investigative scientific or artistic frameworks. Finally, *Design Intelligence System* represents the

[8] The research by design (as referenced to Jonas' deployment and explanation of such approach [2007]) represents research conducted through the proposal of the solution, measuring thereby its consequences and influences on change of the previous conditions which have been aimed at analysis and improvement.

basic form that organizes research procedures, enables their performance, and secures all required elements and features as fixed systemic parameters. The term *intelligence*, by which all of them have been designated, implies the way and efficiency of problem-solving and knowledge acquisition in specific autonomous and systematically guided or organized frameworks. It bears certain connections to both natural ability of information handling, analysis, evaluation, interpretation, transformation, and production in practical or abstract problem-solving, and on the other hand, the artificial system of information storage and processing that has been designed or engineered in order to advance cognitive and intellectual performance towards the established research aims. It has been claimed that all these *Design Intelligence* investigative forms or structures could advance and facilitate research processes and knowledge acquisition in terms of both creating scientific and artistic discourses and taking strategic action. This has been proved through individual studies and application in both theory and practice. It has been assumed that the way in which design problem-solving and increase of cognition efficiency have been realized in these cases and experiments provide valuable examples to approach different situations of this kind with more insight into possible solutions or obstacles, and finally in an "expert and productive ways" (Meirelles 2013, 9). While arguing the *design intelligence system*'s contribution to different aspects of design practice, research science and methodology (some of which have been pointed out by Meirelles, too [2013, 13]), the recommendations for their further advancement and testing in different research contexts remains the final remark of this paper.

Supplementary Material

Discussions

- *Discussion 1 and Discussion 2:*
  https://www.researchgate.net/publication/376186140_Supplementary_Material_Diagrammatics_Design_Intelligence_System_Methodology_and_Strategy_in_Design_Research_and_Science_-_Discussions

Video Material

- *Design Intelligence System*:
  https://vimeo.com/manage/videos/879118733
- Timelines:
  https://vimeo.com/manage/videos/438134603
  https://vimeo.com/manage/videos/235483140
  https://vimeo.com/manage/videos/233836094

Web Material

- https://dciricdiagramma.tumblr.com/
  https://dciricdesignintelligence.tumblr.com/
  https://dciricmicrohistoriesdiaseries02.tumblr.com/
  https://dciricmicrohistoriesdiaseries03.tumblr.com/

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- The Virtual Poster Presentation is available at: https://www.researchgate.net/publication/331812305_Diagrammatics_'Design_Intelligence_Strategy'_in_Design_Research_and_Science.

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- Generative AI or AI-assisted technologies were not used in any way to prepare, write, or complete essential authoring tasks in this manuscript.

Informed Consent

- The author declares that the manuscript is her original work and that there are no other persons who satisfied the criteria for authorship but are not listed.
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- The author confirms that this article does not contain any studies with human or animal subjects.

Conflict of Interest

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Appendix

Definitions and interpretations of the word, concept, or term *diagram* indicated in Footnote 2 have been grounded on information from several sources.

1. In reference to the etymology, the term has been analyzed by consulting the *Dictionary of Standard Modern Greek* (Institute for Modern Greek Studies 1998), namely entries for *διά*, *γράμμα*, and *διάγράμμα*, [9] along with their use in ancient Greek literature including works of Plato, Plutarch, Strabo, Euclid, Aristotle, and others (Crane [online source]).[10]
2. The term's appearance has also been traced in other sources by investigating the usage of the word *diagram*/*diagramma* and its constitutive parts in literature of Latin origin (Crane [online source][11]; Lewis, and Short 1879; Kepler, Fludd, and Ptolomy, active 2nd century 1619), including the concept σχήματα (*schimata*) (Vitruvius 1914; Crane [online source]).[12]
3. These sources have been supplemented with *diagram* concepts from modern and contemporary philosophy, for the most part referring to works of Charles Sanders Pierce, and Deleuze and Guattari, but also many others that have made a significant contribution to the *diagram's* philosophical grounding (e.g., Kant and his concept *schemata*). The number of most recent studies on the topic, primarily centered on the organized initiatives for research in diagrams (e.g., *International Conference on the Theory and Application of Diagrams)*, have been appended to these sources.
4. Further investigations have been left open for supplementary sources and information (Appendix to the note 2 represents the short summary of the author's unpublished research material on the topic of etymology and the use of the *diagram* term and concept).

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[9] *διά*: https://www.greek-language.gr/greekLang/modern_greek/tools/lexica/triantafyllides/search.html?lq=%CE%B4%CE%B9%CE%AC&dq=
https://www.greek-language.gr/greekLang/modern_greek/tools/lexica/triantafyllides/search.html?lq=%22%CE%B4%CE%B9%CE%B1-%22&dq=
Δία: http://www.perseus.tufts.edu/hopper/text?doc=Perseus:text:1999.01.0172:text=Crat.:section=396a&highlight=dia; http://www.perseus.tufts.edu/hopper/searchresults?q=Dia
γράμμα: https://www.greek-language.gr/greekLang/modern_greek/tools/lexica/triantafyllides/search.html?lq=%CE%B3%CF%81%CE%AC%CE%BC%CE%BC%CE%B1&dq=
διάγράμμα: https://www.greek-language.gr/greekLang/modern_greek/tools/lexica/triantafyllides/search.html?lq=%CE%B4%CE%B9%CE%AC%CE%B3%CF%81%CE%AC%CE%BC%CE%BC%CE%B1+&dq=

[10] *dia*: https://www.perseus.tufts.edu/hopper/searchresults?q=dia
gramma: https://www.perseus.tufts.edu/hopper/searchresults?target=en&all_words=gramma&phrase=&any_words=&exclude_words=&documents=
diagram: https://www.perseus.tufts.edu/hopper/searchresults?target=en&all_words=diagram&phrase=&any_words=&exclude_words=&documents=

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