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Evaluation Methods of the Structures' Aesthetics – Part I

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Abstract

Main component in the process of deepening a field, the evaluation was also applied to the topic of structures' aesthetics, within the research conducted for the PhD thesis "Study of aesthetics in civil engineering". The present paper discusses these aspects: the critique of structural aesthetics, evaluation criteria, modern ways of evaluating the structures, the opportunity to implement a Decision System in the process of evaluating the structures with its synthetic presentation, the use of fuzzy logic for the above- a Fuzzy Logic Intelligent Decision System, a short presentation of the main elements of fuzzy logic and concludes with our proposal to apply the previously presented elements in the aesthetic evaluation of structure works. Given that the size of the work is extensive, it has been divided in two parts, the first one here, focusing on criticism discussions wore by the specialized public on the aesthetics of structures, an inventory-guide of evaluation criteria, a short review of the modern ways of assessing the structures' aesthetics and the presentation of the Decision Support System, highlighting its usefulness to our topic.

Rezumat

Componentă principală în procesul de aprofundare a unui domeniu, evaluarea a fost aplicată și asupra temei esteticii structurilor, în cadrul cercertărilor derulate pentru lucrarea de doctorat "Studiu de estetică în inginerie civilă". Lucrarea de față aduce în discuție aceste aspecte: critica asupra esteticii structurilor, criterii de evaluare, modalități moderne de evaluare a structurilor, oportunitatea implementării unui Sistem Decizional în procesul de evaluare a structurilor cu prezentarea sintetică a acestuia, valorificarea logicii fuzzy pentru scopul menționat printr-un Sistem Decizional Inteligent cu Logică Fuzzy, scurtă prezentare a principalelor elemente de logică fuzzy și încheie cu o propunere proprie de aplicarea a elementelor prezentate anterior în evaluarea estetică a lucrărilor de structură. Dimensiunea lucrării fiind amplă, s-a recurs la divizarea sa în două părți, prima, cea de față, concentrându-se pe discuțiile despre critică, purtate de publicul specializat asupra esteticii structurilor, un inventar-ghid de criterii de evaluare, o scurtă menționare a modalităților moderne de evaluare a esteticii structurilor și prezentarea Sistemului Decizional, cu evidențierea utilității sale relativ la tema noastră.

Keywords: structural aesthetics, criticism of structures' aesthetics, structures' evaluation, aesthetics criteria, structures' aesthetic assessment, Decision Support System.

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1. Introduction

The component of assessment in the process of deepening a field is the one that ensures its development, offering the possibility to identify breaches and opportunities in that field.

Following the previous discussions we drove in our PhD thesis, *Study of aesthetics in civil engineering,* on the structures' aesthetics, the visions of world-renowned engineers of the past two centuries and a half, and the visions of contemporary engineers at regional (national) level, it was necessary to approach the current solutions for assessing the aesthetic qualities of the structures.

The purposes of this paper are:
• identifying criticism aspects in the aesthetics of structures and the forms in which they are being developed;
• making an inventory of aesthetic criteria for structures, that serves as guiding lines in design and assessment;
• discussing current assessment ways and methods, in order to bring in the sight the means in which the today's technological progress supports this topic;
• choosing a methodological way to present our proposal for the structures' aesthetic assessment.

Derived from the first two objectives, the synthesizing of the criteria's features that are involved in this evaluation will lead to the search for a particular solution to ensure the results' maximization by exploiting the available resources.

An assumption that this research has started with is that the multitude of important aspects in assuring the aesthetic qualities requires a system vast, integrated and equipped with specialized tools in order to deal with large volumes of information and often uncertain, hard to identify and to define criteria. This system must record the perceptions of the aesthetic qualities of the structures, as provided by the final beneficiary, the public.

The support which our proposal is built on is provided by such a decision-making system, whose features support the topic. The decision-making system being the framework of the decision-making process, a particular variant of it operates with values typical for the aesthetic criteria, namely the Intelligent Decision Support System with Fuzzy Logic. In order to understand how the fuzzy logic works and corresponds to the our concern, the second part of this work will be consulted.

The proposal we are making is an operational link inside the Intelligent Decision Support System working with Fuzzy Logic, designed to be dedicated to our topic.

The whole work has among its objectives the formation of a reflective and critical thinking of the specialist, on the aesthetics of the structures. Achieving this goal results in the emergence of decision-makers with a solid knowledge base of the problem.

Another important matter, which may not be given enough attention during the process of designing and building a structure, is its sensational impact on the community which it is inserted in. As the public is the final end-user of a project dedicated to it, it should also be a pseudo-decision-maker during the project's evaluating. Pseudo-decision-maker, because its opinion is often not properly articulated, rigorously requested and integrated in the process of designing the structure. Our solution places this final beneficiary of the high impact structures on the true position that is in relation to that structure - the public is the real evaluator of the high-impact construction from the public space.

The entire research focuses on the satisfaction of the citizen and the elevation of this satisfaction and the quality of his life by identifying, evaluating and promoting the aesthetic qualities of the constructions. If the citizen is the long-term final beneficiary, then it must also be a decision-maker in the evaluation process. In parallel, the solutions to replace the human component in the decision-making processes through high-performance digital systems diminish, unfortunately, the beneficiary's involvement in this process.

2. Structures' aesthetics critics

The structures' aesthetics is more than just a visual assessment, it has far deeper implications in a project, as it denotes the quality of the design process. The specialist also needs a critical mind on his own project that will lead him to the integrated success of the construction [1].

It is easier to appreciate the structure of the buildings that have left it exposed [2], but in fact the structure of any construction, exposed or camouflaged, conveys to the observer a message with a certain aesthetic, subtle, more sensory, lighter or more difficult to receive content.

The development of a critical judgment is very important for a specialist, in order to divide the structures between valuable and not valuable, even if all may be correct. Valuable structures are due to valuable design and vice versa. It is the mature engineer who recognizes, appreciates and contributes to the integration of aesthetic value into structures [1].

Bill Addis argues that it is necessary to practice the criticism on structures from an aesthetic perspective and proposes the following phases of the process [1]:
• selecting the objects to be analyzed;
• describing each objective in a comprehensive manner. This can come from several points of view:
◦ visual – the features perceived at first glance and those perceived at a more in-depth look;
◦ contextual – the environment in which it is found, the historical, cultural, artistic, social context, including the functions that it needs to serve;
◦ material – the used construction materials;
◦ structural – the mechanical way of working the structural elements, the loads taken and transmitted to the ground, the involved actions and forces, the typology of the structural system, etc.
• description of sensory and affective experiences felt during the direct exploration of each object;
• highlighting the similar and particular aspects of the analyzed objects;
• the last step added by us: ranking by aesthetic reasoning and justifying the hierarchy of objects subjected to all the steps of the analysis.

Being a complex and very subtle feature of both natural and human creation, the aesthetics benefits of tolerance and flexibility in appreciation and evaluation [3], but these also have some limitations that do not allow the inclusion in aesthetics of the objects that really belong to the sphere where are: the ugly, repellent, repulsion, monotony, dislike, failure, disproportion or imbalance.

The aesthetic studies' application can be conducted empirically, by analyzing the projects taken in a row; respectively speculative, generating a few prerequisites that apply to existing projects in order to confirm the initial assumptions [4].

The first combined effort comes from the architect and the engineer, the designers of a building, who will succeed, or perhaps not, embody the aesthetic qualities in a structure. The user-observer is the person which the success of the two instances is reflected toward. If the latter one doesn't feel or doesn't understand the aesthetic value of the construction, whether consciously or not, this is due either to the weaker success of the specialists or to the lack of effort of the third one, who does not have the intellectual and psychological tools to do so, or this is due to all the actors [2].

The extent to which an objective is appreciated by the public shows also the level at which the public has cultivated itself in that area or the level it has been cultivated through several sources of inspiration made available by creative specialists. Satisfying certain environmental needs allows the observer to identify and evaluate the aesthetic qualities of an objective. However, the lack of appreciation of a structure's aesthetic value in its true measure sometimes betrays the opacity, ignorance or disinterest of the public for art and science [5].

When the public starts to express their views on the built environment and the psycho-emotional impact it generates on the community [6], then the specialists start to realize the significance of the aesthetic valorization.

The design of structures with aesthetic value implies the capitalization of a wide range of resources available to the specialist: the scientific and technical basis, the execution technologies, the design methods, the structural shapes, proportions, spatiality, functionality, order, the harmonization of elements, the construction materials, miscellaneous qualities of the materials, the mechanical working ways of the structural elements, the ways of working together as living parts, the artistic meanings, the message transmitted by the construction and, last but not least, the financial resources.

3. Evaluation criteria

The proposed criteria, identified during the research in the doctoral program as relevant for the aesthetic evaluation of the structures, are included in the below summarized categories. These are our subjective proposals that may or may not coincide with what other specialists would consider relevant.

Most of the criteria are abstract nouns, and the aesthetic value answers questions such as: *To what extent does the structure have, assures, reflects, conveys, transmits, denotes, contributes to, inspires, encompasses, surprises, registers, respects, etc. ...?* [that criterion] whether or not followed by an adjective characterizing the noun, e.g. *good, suitable, appropriate, adapted, exploited, high, performing*. Some of the noun criteria refer to objects, especially building materials, for which the question arises whether the *Structure uses, implies, predominates in, attracts ...?* [that material].

Another part of the criteria are adjectives for which the question is asked whether the *Structure is ...?*

A small part of the criteria are actions (verbs) against which the question arises whether the *Structure: responds, valorizes* (contributes with added value in that aspect, not necessarily exploiting that aspect) etc. Here it is also offered a brief explanation.

The assessment of a structure implies not only the identification of the criteria they meet or not, but also the degree to which they are satisfied and, finally, which criteria are satisfied to such an extent that they contribute to raising the overall level of aesthetic quality of the objective.

The categories and criteria identified are as follows:
1.Mechanical criteria – count those criteria for the mechanical conditions that a structure must meet to be firstly valid, and then to denote exceptional qualities in these respects: strength, stability, efficient take-up of loads, load driving on the ground, mechanical efficiency, mechanical

performance, respect of the mechanical principles with simplicity, simplicity, complexity, mass balance and stiffness.

2. Technical criteria – refer to the technical aspects involved in the design and execution processes: technically feasible, constructive, refined in detail.

3. Functional criteria – look at the connection between structure and function: coherent functionality, functional performance, functional comfort, corresponding conceptually, thematically appropriate.

4. Formal criteria – propose items that grant formal qualities to a structure: form appropriate to function, volumetry, visual appearance, spatial coherence.

5. Scale criteria – identify the extent to which the dimensions of the structure contribute to the enhancement of its aesthetic qualities: overall size of the ensemble, amplitude, magnitude, scale, monumentality.

6. Materials criteria – follow the typology, qualities, quantities, rationality and motivations which the building materials were selected and distributed in the structure with: the economy of materials, locally available materials, quality materials, compatible building materials, materials empathic with those in the neighborhood.

7. Criteria related to science – refer to the scientific pluses that the development of the project and the implementation of the structure attracts with its own: scientific input, innovative character, originality, inspired, intelligent, dynamic, adaptable, able to evolve, reflects a in-depth scientific research.

8. Environmental criteria – take into account the impact the structure has on the environment and how it has adapted and contributed to the valorization of the environmental elements through its realization: adapted to topography, aware of the environment, responsible for the environment; values the topographical, geographical and natural resources in the vicinity; transparency and opacity in relation to neighborhoods, sustainability, harmonious to neighbors; integrated in the urban context: alongside nearby buildings, quarters, localities; climactically appropriate, pays attention to the environmental factors: wind, precipitation, natural lighting and shading; appropriately oriented in space (according the cardinal points).

9. Indoor ambient criteria – consider the effects that the structure produces in the indoor environment and which it transmits to its user: transparency and inner opacity, inner harmony, intuitiveness in exploitation, visual comfort, valuing the natural lighting and ventilation.

10. Sensory criteria – refer to the manners and measures in which the user's senses are involved in the exploitation of the objective: sensory comfort, allusive perceptual, emotional impact, perceptual nuances, sensory content.

11. Social criteria – denote the pluses that a structure generates over the community it serves: social contribution, social potential, public appreciation, social success, local landmark, politically appropriate, adapted to its time, adapted to the society's progress, addresses the society's needs, responds to the community's problems, stimulating the community.

12. Cultural criteria – reflect the impact from the point of view of the cultural progress, which the structure generates: cultural value; cultural contribution, impact, added-value; cultural potential, artistic vision.

13. Intrinsic aesthetic criteria – include features whose evaluation is subjective and mirrors a person's own vision: elegant, graceful, interesting, exciting, appealing, extraordinary, spectacular, extravagant, ecstatic, rational, expressive, refined, creative, surprising, pleasant, symbolism; sense, significance, poetic content.

14. Financial criteria – indicate the rationality of the used financial resources, but also the extent to which the structure will require financial resources during its use: minimum material costs, minimum cost of execution technologies, minimum labor costs, minimum cost of the current use, minimum maintenance.

The above criteria may guide the evaluation of a structure, but, as it may be seen, the information available for the structure in question must be extensive in order to allow an objective assessment. In a real situation, the decision-makers body needs a wide range of data: design and execution plans, technical statements, virtual simulations, models, 3D digital explorations, financial statements, impact and feasibility studies, sociological studies, collections of opinions from the public who got acquainted with the structure, etc. An important category is mentioned in the section 4.2. *The Decision Support System in the aesthetic analysis of structures*, namely the heterogeneous information. They can be expressed in any form of opinion or relevant assessment criterion coming from the public or the decision-makers, that can reveal aspects not initially taken into account but which may have a real impact on the project.

The inclusion of as many criteria as possible in the discussion on a structure is not only a form of in-depth assessment of the aesthetic value, but also an effective way of provoking the creative power of the specialist.

4. Ways and methods of evaluating the structures

4.1 Modern ways of evaluating the structures

There is, of course, a tradition in engineering and this can not be denied because it is primarily based on scientific principles. It must, however, be used to support the reinterpretation of the old in the context of new resources and to assimilate the advances in technology and science within civil engineering.

Deepening and understanding the structural principles lead the engineer to exploiting his or her creative potential. The specialist needs to know their tools, the material and technical limitations and freedoms, besides the *rules of the game*, and then to want to create extraordinary works. With a dose of innate intuition, the engineer can create objects of high artistic engineering value, thus being a creative genius. The current technical progress also allows other specialists, with less intuition, to excel if they deliberately add a dose of genius value to a regular project, filling-up with the contribution of the increasing technical progress.

Modern methods of testing and evaluating the structures, as mentioned in [7], are summarized below:
• the finite element analysis, which involves meshing the structure into elementary components, whose behavior, as a whole, should correspond to the actual way the structure behaves at a mechanical level;
• the formal comparative structural analysis, which takes into account the forms of several objectives in the same functional category as the main building;
• the topology analysis and the technical optimization proposal, within the CAD, that identifies the optimum material distribution or the optimal geometry for a given structure;
• the Non-Uniform Rational B-Splines method of isometric analysis, a geometric numerical modelling technique, which identifies and proposes the shape and the optimum distribution of material simultaneously or synchronously.

The methods of evaluating and optimizing a structure's compliance are tools of a very high utility and efficiency, strongly supporting the design work, but primarily encouraging the creativity. Many avant-garde solutions and proposals have struck over time the lack of scientific and technological support, but to a large extent the lack of means of assessing and rationalizing their viability. By resorting to verification and confirmation methods to apply on the projects, the specialist is now able to demonstrate that his courageous ideas are feasible, will be viable, and therefore the innovation and improvement of their implementation lead to aesthetic success.

4.2 The Decision Support System in the aesthetic analysis of the structures

4.2.1 Introduction to the Decision Support System

The evaluations are processes that take place continuously, uninterruptedly, consciously or subconsciously, in concrete or abstract forms. These features of the evaluation processes have several utility justifications.

The first utility of evaluations results from the need to identify the current state of dissatisfaction with a view to proposing improvements. The solutions to improve the current situation have one of the sources in these evaluations. Another utility, seen and practiced by cautious professionals, is to identify the effects of building an object that is being designed, before it is made up. A third utility is approached by visionary specialists who, before beginning the creation and designing process, want to identify the real and actual context to which they will target a commanded object.

About the revolution that computer and the artificial intelligence have brought into the history of humanity we know quite a lot of our own personal experiences, and there are many sources written very well by other specialists so far, as in the Romanian space are: Ioan Alfred Leția (TUCN), Zsongor Gobesz (TUCN), Mihaela Colhon (University of Craiova), Mihai Gavrilaș ("Gh. Asachi" University of Iași), Gelu Chisăliță (TUCN) and many others, and that is why we will not insist here. In the field of the decision-making systems, we can also mention a few specialists from Romania, from the Romanian Academy in Bucharest Florin Filip and Ion Istudor, but also Vasile Prejmerean (BBU), Loredana Mocean (BBU), Georgiana Marin (The Romanian-American University of Bucharest) and others. In the section dedicated to intelligent decision systems using fuzzy logic, we mention here: James. R Nolan (Siena College, New York), Fabio Blanco-Mesa (Antonio Nariño University, Columbia), José M. Merigó (University of Chile), Anna M. Gil-Lafuente (Barcelona University) and others. In the section dedicated to the fuzzy logic contributions, we recall: Lofti Zadeh, Florin Lişman (TUCN), Gabriel Oltean (TUCN), Mihai Gavrilaș ("Gh. Asachi" University of Iași), Mihaela Colhon (University of Craiova), Mihai Ivanovici (Transylvania University from Braşov), Gabriela Proştean (Politehnica University of Timişoara) and many others, which unfortunately we will not enumerate here, due to space reasoning.

A matter that we propose to solve through this article, with the help of the current technologies, is the aesthetic evaluation of the structures in a predictable and controlled manner. This is possible by implementing an intelligent, expert kind of decision support system, based on knowledge, that uses fuzzy logic elements, as an initiative to exploit the tools specific to the field of artificial intelligence. Mihai Gavrilaş also notes that the aesthetic impact of some objects can best be addressed by fuzzy sets, using linguistic values [8].

In order to prepare the grounds for the presentation of the Decision Support System (DSS), some key concepts of the decision-making process are described below.

The **decision** is the process through which a choice is made in order to achieve a goal to the fullest extent, attracting the minimal inconveniences and the minimal resource consumption, following the evaluation of each option regarding: the decision method, the variants of the resources' use and the package of effects derived from this process [9].

The **decision-maker** is the person involved in such a process, either by initiating, supporting, influencing, determining or doing it in a plenary form [9]. He or she must not necessarily belong to the management structure of a company, but may be a member of the team whose activities also include decision-making processes, identifying a choice with significant effects for the purpose of the performed activity.

The **decision-making process** consists of the succession of steps by which the resources invested to achieve the goal of the decision are used in the most efficient way in order to achieve the best results. H. Simon proposed in 1960 [10], and in 1977 he revised [11] the four steps of this process, still valid today: information → identification of alternatives → selection → implementation with evaluation. Their order or duplication in the decision-making process can vary and can be adapted to each case.

The **specificity of the decision** constitutes the objective of this paper, the answer to the question: *What and how does qualify the beauty, the aesthetic value of a structure?,* and is presented as follows:
• the approach: reaching the goal of the decision-making process requires in-depth analysis, rigorous systemic modelling, high predictability and the use of the richest knowledge base;
• the context: the need for the decision-making process is episodic, being occasioned by every project of importance or impact on the public. The latter is an essential component for the construction's success confirmation;
• the structuring: the topic has a semi-structured content, being partly unstructured, because the matter of defining the beauty is vague, complex in its nature and subjective;
• the importance: high, through the scale of its effects on the public, demanding a lot of creativity, considerable resources for exploring the topic and tools, and involving the public in the process;
• the uniqueness: every decision-making process is unique and applicable in a fully dedicated manner to the topic;
• the amplitude: the chances of success of the implementation increase with the involvement of a wider segment of the public, in addition to the expert body that manages the process, and this increases considerably the number of participants in the process.

The decision model applied to our topic. There are many decision-making models presented by the specialists already mentioned [9], but the one taken, adapted and completed in order to correspond to our topic, comprises the following 12 determinant steps:
1. Understanding the topic
1.1. Understanding the concept of *beauty*
1.2. Understanding the beauty of structures
2. Identifying the problem
2.1. Observing the current situation in the field of construction and the existing shortcomings
2.2. Understanding the severity of the problem and the need to bring about a change
3. The purpose's presentation
3.1. Becoming aware of the importance of creating structures with a high aesthetic value
4. Identifying the methods, means, resources needed to reach the goal
4.1. Investigating the ways in which beauty becomes a real component present in structures
4.2. Investigating the specific means of civil engineering through which the beautiful becomes integrated into a structure
4.3. Researching unusual, the most recent and able to be adapted to the problem methods
5. Identifying the necessary resources for the implementation of the used methods, as identified at the previous step
5.1. Identifying the technical, scientific, philosophical, technological and human resources which contribute to the exploitation of the means
5.2. Researching on atypical resources, recently discovered and adaptable to the topic
6. Proposing the implementation options
6.1. The particular case: this section of the paper proposes to create a micro-decision system on the aesthetic evaluation of the structures, combining a knowledge base which the specialized body operates with and the opinions of perception and evaluation of some structures that the public offers to them

7. Evaluating the proposed variants in terms of the means, the resources involved in the implementation and the effects it generates
7.1. Our proposal is based on the following reasoning:
• it uses modern means of implementation;
• it attracts the most updated dedicated resources – see the presentation of the software in the second part of this article, created with the unique and clear purpose of helping to solve this matter;
• it has virtually unlimited availability, the questionnaire for the public can be completed by anyone who knows Romanian, wherever he or she is, as long as there is an Internet connection to access the questionnaire and send the answers;
• it is able to collect a large amount of public opinions, which means that the evaluation acquires a high degree of accuracy;
• it is a very accessible, flexible and adaptable solution to the public's responses, as can be seen from its description in the second part of this article, which makes it a solution with high scalability.
8. Selecting the variant that generates the highest positive effects
8.1. It may be dedicated to the pre-assessment of some structures in the feasibility phase of the project in order to choose the variant that leads to the highest satisfaction offered to the beneficiary public of the structure or it may be dedicated to the context in which an evaluation is followed by a ranking of the structures
9. Implementing the winning variant
9.1. It means either to continue the design of that chosen structure, with its execution, either the establishment of the ranking and the recognition of the aesthetic qualities held by the winning structure
10. Evaluating the real effects of the winning variant
10.1. An essential step in the context of choosing a structure to be built up as a new insertion, a reconversion or a rehabilitation in the urban tissue or the environment which it was placed in
11. Comparing the real effects of the winning variant with its effects identified in step 7
11.1. The last step evaluates the decision-making methodology, its success and its efficiency.
12. Synthesizing the intellectual gain generated by the entire process and the capitalization of information in the Knowledge Base of the system.
12.1. The capitalization of the intellectual gain is a feature of Expert Intelligent Decision Support Systems.

The model presented here, customized on our topic, seeks to obtain some information based on which the decision-maker can proceed with the final decision making, given the following features:
• it attracts a high or very high human intellectual effort to carry out the processes involved: analysis, understanding, generating options, comparison, selection, implementation and post-evaluation;
• it involves a huge amount of specialized information, of a complexity sometimes uncertain and with varying degrees of subjectivism;
• it operates with concrete information, but also with blurred, incomplete, partial, dynamic information, in a continuous generation process;
• it requires a continuous process of data collection, integration and processing of new knowledge;
• it must be aware of the latest news from the involved fields of activity;
• it looks for ways to exploit the new resources in order to maximize the effects and to continually exceed the maximum performance threshold that is characteristic at the moment.

These features are found in the Decision Support System (DSS), a tool specific to the field of the Artificial Intelligence. In order to support the purpose of our topic, the DSS is further presented.

4.2.2 Brief Overview over the Decision Support Systems

Defining the Decision Support System

There are many DSS definitions that have been offered along the time by specialists, which is also very useful because each of them touches one or more essential aspects in understanding the concept. Among them are also: Gorry and Scott Morton (1971), Ginzberg and Stohr (1982), J. O'Brien (1999), C. Brândaș (2007), Florin G. Filip (2007) [16], Ion Istudor (2009) [9], Georgiana Marin (2011) [13], Vasile Prejmerean (2017) [15]. The one we propose follows here:

The Decision Support System is a flexible, dynamic, capable to evolve complex of information, working methods and intellectual resources, that helps a decision-maker to deeply define a strongly or poorly structured non-common topic, to identify its potential and probable alternatives, to evaluate the costs and the effects of each alternative, in order to make the final choice in the deepest awareness.

The DSS core is the engine for managing the entire complex and generating the final option. Its purpose is to diminish the human limits in the decision-making process [9]. The DSS may present some facilities, such as supporting the realization, with specific means, of the best communication among the involved people, or the shape up of a user-friendly interface.

Characteristics of the Decision Support System

To clarify the above ones, the features of a DSS are further shown – see also [9],[12],[13],[14],[15]:
• it is a flexible, growing information system, both as dedicated information content and as involved technologies;
• it aims to provide pre-evaluated alternatives to problems that are difficult to structure or fully define;
• it can contribute to all stages of the decision-making process carried out by the decision-makers body and can also support several types of decisions [9];
• it is a multifaceted tool, being able to simultaneously perform several functions: reasoning – based on the rules of reasoning, it generates new knowledge that it presents and argues in front of the decision-maker; simulation – it provides full scenarios for the available variants; evaluation – it owns the necessary means to make pre-assessments of the resource consumption, the generated effects and the benefits of each option; prediction – following the simulations and evaluation of the best options, it generates the complete scenario of the consequences of making a certain decision; learning – the solution-generating module is able to capitalize information from one project to the other;
• it seeks to maximize the effects of the final choice, not necessarily only choosing the most effective solution for the moment, but also targeting the future effects [15];
• it uses decision models that it adapts and enriches accordingly;
• it is keen on innovations and news on the topic;
• is a tool with a high degree of flexibility regarding:
◦ the hierarchical position of the decision-maker it helps: dedicated to various types of decision-makers, located anywhere on a managerial scale, as the position of a person assigned to make a choice can be anywhere in an organization;
◦ the topic: it supports the identification of the best options for miscellaneous, poorly defined or undefined issues, but the degree of defining the problem will impact the complexity of the process;
◦ the impact: the DSS can be used for a one-time decision or for a large-scale decision chain to help a person or a group of people;
◦ the presentation form: it may be dedicated to a closed-loop problem, where only a small group of people have access, or to an open circuit, when it can involve many people in the stages of the

process;
◦ the information: it allows for the addition of new information and new rules of reasoning dynamically (during the process of decision-making);
◦ the evolution: it may be developed continuously by the programmer;
◦ the end: the DSS supports processes whose goals may range from doing research to get to know a topic and gaining as much knowledge as possible, similar to an extensive knowledge base, to proposing variants to design and implement a construction, to predict the fingerprints of each variant, to propose ways of implementation and to evaluate the whole investment-benefit framework for a chosen hypothesis.
• it is interactive and adaptable because it allows the user to expand the issue's description, to enrich its knowledge base and its operating rules;
• its control is in the hand of the decision-maker for whom the DSS is a working tool. The DSS never makes decisions alone, thus, the DSS is defined as being anthropocentric [16];
• it attracts the development of the complex that revolves around it and around the involved technologies, namely: Data Warehouse, Data Mining, OLAP (On-line Analytical Process), Expert Systems, Artificial Intelligence tools, in order to consequently to enrich the field of Business Intelligence [9];
• it uses a *shell* that is the technical means of aggregating and storing information, pre-defining rules, and building the User Interface so that the user can present the situation in a comprehensible shape for the DSS;
• it can be an open system that, with the ability to evolve, can accumulate more knowledge, more rules of reasoning, can devote to several domains at once, can use information from several domains to offer atypical variants to a particular field;
• it has, therefore, a wide range of variations and architectures.

Characteristics of the Particular Decision Support System

The particular decision support system (PDSS) of our topic, pursuing prediction and control, differs from the standard DSS through the following features [9]:
• it is dedicated to a field that is more difficult to define and outline, operating with partial, not fully defined, subjective, momentary, fluctuating, temporary information;
• it uses intellectual resources divided in two categories: provided by aesthetics and structure specialists, respectively provided by non-specialist people from the target users of the project;
• it uses knowledge stored in advance in the knowledge base, along with dynamic data and, at least in the first instance, temporary data;
• it works on the basis of two sets of rules dedicated to the two types of knowledge: clear predefined rules for the rigorously knowledge inserted by experts, respectively elastic rules dedicated to dynamic knowledge, that follows the fuzzy logic described in the following section;
• it is essentially composed of prior knowledge, dynamic knowledge and open connections (so-called to differentiate the connections that are made through the pre-implemented rules, from the rules introduced during its use, being able to operate pseudo-arbitrarily, while receiving new external rules from the public user which integrates them dynamically and momentarily);
• it supports the bidirectional chaining, i.e. it uses the back and forth links;
• it aims to solve problems that are not difficult in form, but it is difficult to solve them in essence;
• it must provide not the best response that can be offered at the moment, but the answer that has the best effects propagated over time;
• it must provide a response to a situation that is a challenge for both the human expert and the classic DSS;
• it is dedicated to solve problems characterized by both known and existing parameters, as well as probable, unknown, temporary parameters, in process of integration into PDSS;
• it seeks to continuously verify and improve its knowledge by interacting with the respondent from the public, and based on dynamic knowledge to provide anticipated evaluations or control over the

objectives;
• it is creative and, in the absence of a fully viable solution, proposes partly good variants, specifying the consequences of choosing them;
• it learns ways of thinking and feeling from the respondent.

Disadvantages of the Decision Support Systems

Alongside the advantages clearly highlighted by the DSS's features, there are some disadvantages that must also be mentioned [9]:
• the decision-maker may tend to diminish his or her responsibility for the made choice, which is incorrect because the DSS is anthropocentric by definition;
• the decision-maker may feel compromised by the DSS on his or her role in the decision-making process because the DSS holds more information, but, in reality, the man will never be able to be replaced by a machine. Here we mention that we do not subscribe to the belief that in future the robots will take on basic functions in the human life, such as the digital teacher, because it is sufficiently known and demonstrated that the man, a social being by definition, needs human authentic affection in order to shape healthy emotionally and intellectually. Despite the fact that these smart and almost human robots will enjoy certain advantages, they will never be genuine humans;
• the decision-maker may feel overwhelmed by the amount of information that the DSS puts at his or her hand;
• the decision-makers or the final beneficiaries of the decision-making process may have misconceptions about the DSS, for example that the DSS offers solutions that are too rigid or inappropriate to the final effects over the human component of the consequences, or that the DSS raises whole alone the level of objectiveness of the decision-maker, but in fact not the objectivism level it raised, but the level of professionalism as an expert;
• the DSS can not be applied to any situation, even if the DSS's knowledge is constantly expanding and improving;
• building a DSS involves a high or very high human intellectual, informational and technological effort, which can discourage the desire to use it;
• using a DSS requires some intellectual effort that sometimes the decision-makers are not willing to make.

Typologies of Decision Support Systems

The miscellaneous concerns about the DSS have led to the emergence of a wide range of them, classified in several families [9],[13],[14],[15], which are briefly presented below:

• according the system orientation, there are:
◦ data driven DSSs – are dedicated to collecting as much information as possible from an area, according to certain criteria, in order to be made available to the decision-maker;
◦ model driven DSSs – based on *what-if* analyses, simulations, optimizations on mathematical models, typically using lesser amounts of information, whose limits and parameters are clearly specified;
◦ knowledge driven DSSs – involve a Knowledge Base and a typology of the Expert System, being dedicated to situations unable to model mathematically. They support the decision-maker by offering well-proven variants from the Expert Knowledge Base; they involve Artificial Intelligence technologies and applications such as data mining and data management;
◦ communications driven DSSs – aim to facilitate the communication inside the decision-makers team by technological means such as World Wide Web, client-server, teams, working teams, working communities, ensuring the transmission of data content and including visual and audio support, also during the teamwork conferences;

◦ document driven DSSs – widespreadly coagulate incompletely structured and unstructured information from a domain without clearly defined criteria, presented in various forms: texts, data sheets, web pages, documentation and databases, with the main purposes of identifying and store this information in order to be made available to the decision-maker.

• according the impact on the decision-making process [9],[12],[14], there are:
◦ DSS as an application – designed specifically for a particular issue in the field of affiliation;
◦ generalized DSS – used to generate the general and specific constituent elements of DSS;
◦ DSS as tools – used to create dedicated DSS;

• according the size of the deciding body which they are intended for [9],[13],[14], there are:
◦ individual DSS – used by one person to achieve the goal of making the best decision in a situation;
◦ group DSS – dedicated to a small group of decision-makers, hierarchically homogeneous or not;
◦ DSS of the organization – available for the expanded and hierarchically non-homogeneous group of decision-makers from an organization;

• according the type of the provided support [9],[12], there are:
◦ passive assistance DSS – for retrieving the stored information, via simple commands;
◦ traditional assistance DSS – for evaluating and quantifying the effects of choosing a particular variant;
◦ standard assistance DSS – for optimizing the variants using mathematical models or for retrieving variants from the available information pool;
◦ cooperation assistance DSS – referring to the cooperation between the system and the decision-maker who refines the variants received from the DSS, so that the latter reevaluates the selected variant;
◦ extended assistance DSS– when the DSS is a proactive pseudo-decision-maker, leaving the final decision to the man's discretion, stimulating him or her with variants and helping out by taking some tasks from him or her;

• according the core technology that they focus on [9],[12], there are:
◦ DSS focused on texts, documents and data sheets;
◦ DSS focused on databases and, respectively, on knowledge bases;
◦ DSS focused on rules;
◦ DSS focused on solving;
◦ DSSs focused on the World Wide Web or other networks;

• according their technical flexibility [12],[14], there are:
unsmart DSS – can solve only some template issues;
smart DSS – can solve new problems by analogy;

DSS with rigid commands – the decision-maker is limited by the default DSS commands;
DSS with natural language – the decision-maker uses a language very close to the natural one, within the communication with the DSS;

synchronous DSS – provides instant real-time responses;
asynchronous DSS – can not provide instant responses, but only after a certain amount of time required for processing;

DSS with centralized resources of the information system;
DSS with these resources dispersed;

DSS with automated processes for analyzing and designing the information system;
DSS with manual processes for these purposes.

Roles involved in a Decision Support System

Florin Filip brings to mind in [16] a particularly important aspect about the person involved in a DSS and his or her responsibility, stating that: *"it would be fair to attribute the responsibility entirely to the decision-maker if he has built a DSS for himself, using primary IT tools, he took the decision without being influenced by any decision-making assistant and drove it himself"*. When the entire responsibility comes to the unique decision-maker, this is also the sole participant to its use, he or she fulfills all the human roles involved in the design and the use of DSS.

In real life, more people are involved in a DSS and they formally or informally divide the responsibility for the final decision. The categories of people involved are as follows [9],[15]:
• the programmer – creates in a programming language the software on the basis of which the DSS will run;
• the Knowledge Base and rules head – makes the transition between the programmer and the field expert, taking care to populate the Knowledge Base, the model and rules bases, maintenance and upgrading;
• the field expert which the DSS is dedicated to – provides the programmer, directly or through the knowledge base head, with those information (knowledge) that shape up the knowledge base and decides how to collect information outside the expertise, from the public, from randomly selected people, from the final beneficiaries of the decision;
• the end-user – is the decision-maker, as described at the beginning of this section, which interacts with the software through a graphical interface as friendly as possible and which, in the DSS proposed for our topic, also fulfills the role of pseudo-expert in the field, contributing to enriching the Knowledge Base.

The same person can perform several roles in a DSS, and also many people can perform the same role at once in a DSS.

The architecture of the Decision Support System

Schematically, a DSS is made up of the entities in Figure 1, easily adapted to reflect the PDSS's goal, namely to improve the quality of the community life by selecting and implementing those structures that show at least a high level of aesthetic quality.

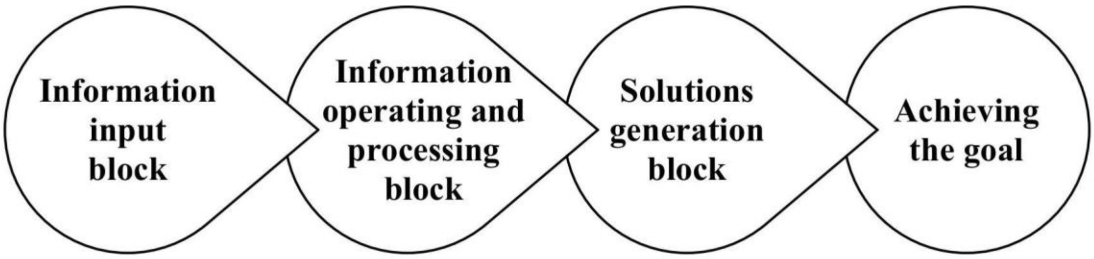

Figure 1. The constituent entities of a Decision Support System

The main components of the DSS, which ensure its operating and achieving the purpose which it was designed for, are, as also mentioned in [9],[12],[14],[15]:
• the Data Management Subsystem (DMS);
• the central Knowledge Base Management (KBMS) module;
• the Model Management Subsystem (MMS);
• the User Interface Management subsystem (generically marked with UI, but in fact the UI is only one component of this subsystem);
• the Infrastructure subsystem (I);

• the Heterogeneous information module.

The last component, the heterogeneous information module, sums up various sources of information, data, external, random and changeable technologies and tools, found in all the other components, symbolizing the power of a DSS to capture the new and to dynamically integrate it. Elements of this component are included in the descriptions of each component, as shown below.
Schematically, these main components of the DSS are shown in Figure 2 and described in the following paragraphs.

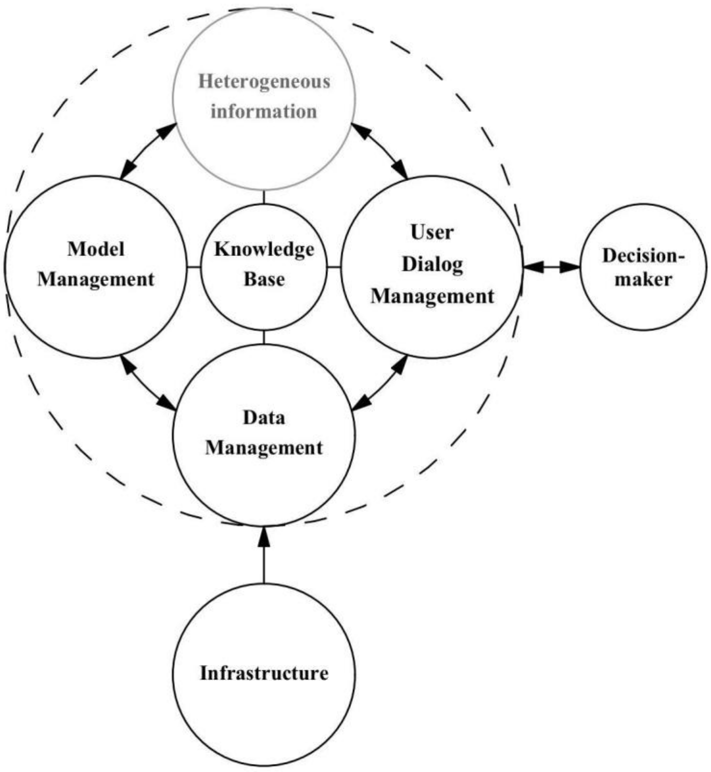

Figure 2. The main components of the Decision Support System

The Data Management Subsystem

The data complex of a DSS includes – see [9],[14],[15] – as expected, more than the total gathered information, more precisely the following operational structures too:
• the data storage structure, which covers the entire informational complex;
• the data processing structure, which uses the appropriate technological tools to manage, process and query the information;
• the data protection structure [15], which, at the same time with the GDPR event, has become an even more important component of the DSS, providing data protection by dedicated software.

The categories of information that can be found in this DSS subsystem are: databases, knowledge bases, the knowledge base of the organization which it belongs to, data collections, internal and external data of the organization. These work with the involvement of a Database Dictionary.

A central component of this subsystem, the database can become vast by aggregating internal and external DSS data, accessing the company's intranet, the Internet, external data warehouses, data collections, and any other heterogeneous sources that may be of interest to the DSS objective.

There are three terms addressed to generic discussions of information, which have subtle semantic differences: data, information and knowledge. The data are raw information to be processed in order to be included in DSS in a validated form, giving it a clear value. The information are those consistent data, integrated into the data management, that the DSS is about to perform. The knowledges are to be further discussed in the DSS Subsystem of the Knowledge Base.

The Database Dictionary consists of an extensive inventory of these ones, which facilitates the users or decision-makers to use the query function through the database query tools. These tools are also a component of the UI, performing the role of retrieving, conforming, updating, querying, reporting, and generating the response to the user request.
The schema of this DSS subsystem is shown in Figure 3.

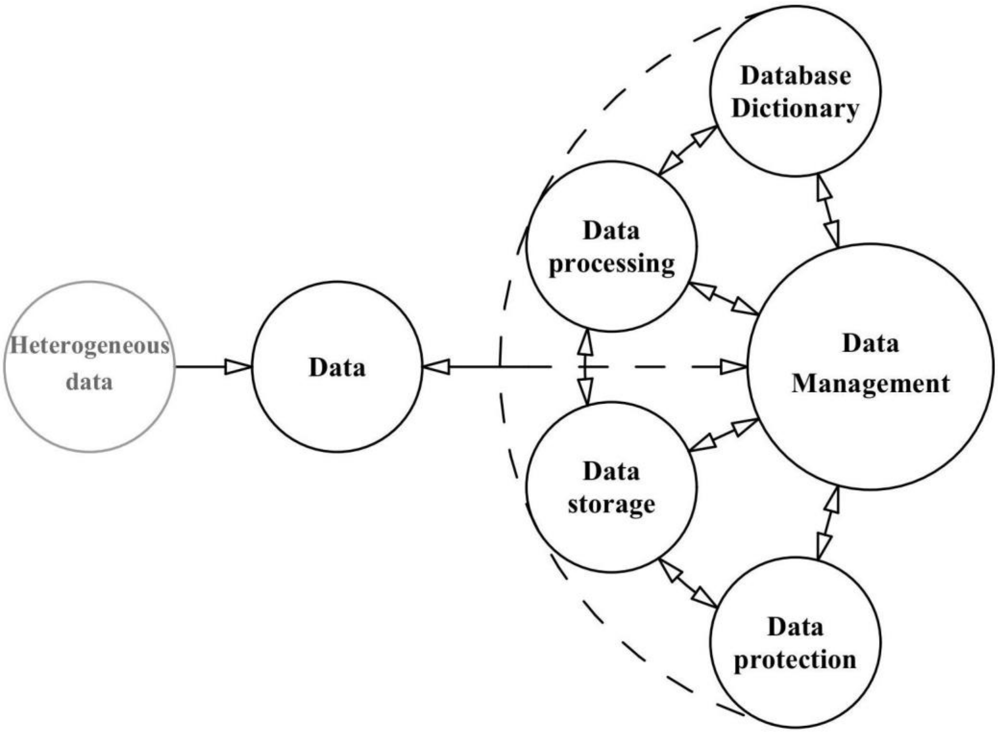

Figure 3. The components of the Data Management Subsystem

The Knowledge Base Management Subsystem

While the DSS Data subsystem may be less specialized, the Knowledge Base subsystem attracts the latest, most performing and sophisticated technologies, aiming to overcome the limits of the current capabilities in the decision-making area, not just to touch.

The Decision Support System that attaches a great importance to coagulated knowledge is also called Intelligent or Expert DSS, having the following features:
• it involves a rigorous process of empirical acquisition of information (directly from experts, but more cumbersome), semi-automated or automatic [9];
• it performs the operations of: collecting (acquiring), structuring, checking, abstracting, inferring, assessing and validating knowledge;
• it has the ability to mimic the learning process from man to passively enrich itself;
• it is dedicated to situations requiring a high or very high degree of expertise;
• it involves a body of human experts whose knowledge is imported into the Knowledge Base directly or with the help of the Knowledge Base head through processes of abstraction and inference;
• it can work in conjunction with external structures such as the expert system, the neural networks,

specific intelligent agents of the AI, casuistic systems, fuzzy logic, and so on [15] or may include subsystems of the mentioned ones;
• it favors the synergy of the DSS subsystems [14].

The structure of the Knowledge Subsystem, pretty similar to the Expert System's one, takes the adapted form from Figure 4:

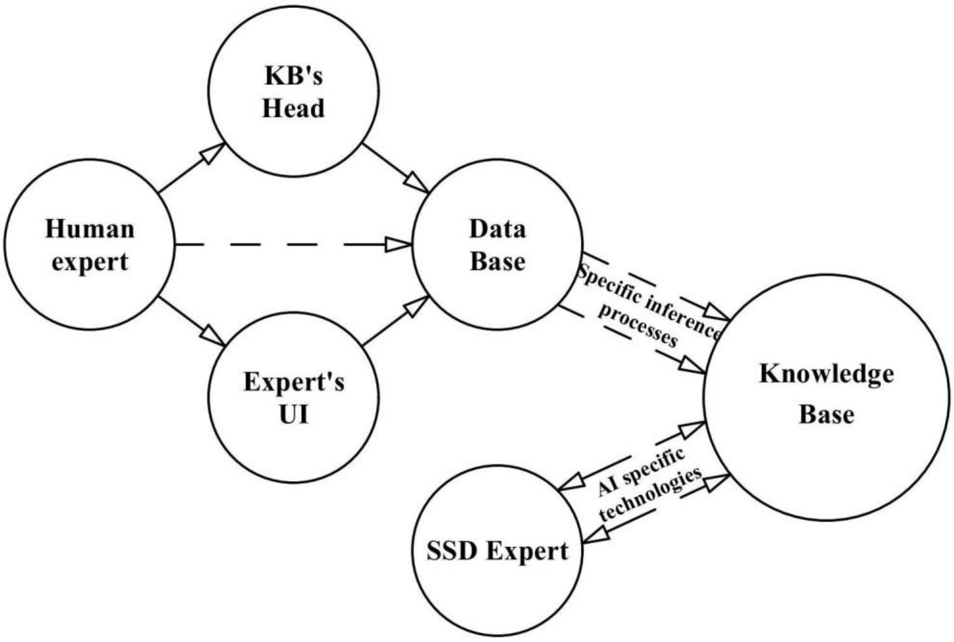

Figure 4. The components of the Knowledge Base Management Subsystem

The Knowledge Base sums up all the knowledge, initially heuristic, collected, filtered, organized, processed and stored in the DSS as rules of event conditions. Gelu Chisăliţă identifies and describes the types of knowledge found in an ES's Knowledge Base [17], similarly found in a DSS. These are presented below, adding examples for each of them:
• heuristic knowledge – "raw" information coming either from the field experts (accumulated information, past experiences, experiments, own reasoning), from previous knowledge bases, magazines, books, other scientific and technical support, or PDSS, from people in the public, after this information has been linguistically validated and considered relevant;
E.g. *I think the shape of the structure is important for it to be aesthetic.*
• declarative knowledge – information organized in the form of statements, definitions and descriptions, selected from heuristic knowledge or processed from them to be presented in the mentioned shape;
E.g. *The shape of the structure is a criterion for the aesthetic evaluation of the structure.*
• structural knowledge – functional information of the DSS that denotes the necessary components of declarative information or instruction, for it to be relevant;
E.g. *The user or the expert must name an object (noun) or process (the present participle of the verb) and assign a quality, attribute or trait to it (at least an adjective or an adverb that determines the mentioned object or process) in order to integrate the information into the Knowledge Base.*
• procedural knowledge – contains methods and methodologies to address or solve a situation. In the PDSS, they pursue a way of justifying, motivating, arguing the opportunity to integrate the "discussion" between the respondent or the expert and the PDSS, more precisely if the way the man judges helps to enrich the knowledge base;
E.g. *A simple statement like "This form is beautiful" is an incomplete assessment. But the statement "This form is beautiful because it reminds me of a flower that was growing around my house in my childhood" provides a useful justification for the made assessment.*

• meta-knowledges – *functional* information of the DSS through which it knows how to use the knowledge base and how to achieve its goals which it was designed for.
E.g. *The DSS dedicated to the aesthetic assessment of the structures aims at collecting the exhaustive list for the present time of categories and evaluation criteria, described exhaustively on the basis of the suggestions and motivations of the experts and the consulted public, for the anticipated evaluation of the projects proposed in the feasibility phase.*

The Model Management Subsystem

This DSS component contains and manages quantitative documentation and decision-making templates. It is made up of the following items having specific roles [9],[14],[15]:
• the model base – runs analysis and resolution processes within the DSS, using the full range of available models: routine information, statistics, forecasts, financial, management, and scientific data. The typology of the DSS models is presented extensively, among others, by Ion Istudor in [9];
• the model base dictionary – represents the inventory of the available templates, accompanied by their definitions and their availability parameters, which is designed to ensure the integrity and the consistency of the subsystem;
• the model processor – accepts, interprets and integrates generating instructions of the chosen model, as received from the user, and combines the available models. For that, specific programming technologies (programming languages) and dedicated applications are used;
• models management subassembly (the Rules System) – it has the roles of: supervising and evaluating the model processor activity, updating the model base, stimulating the generation of new models, assuring the whole subsystem maintenance and the smooth operation of the UI with this one.

The Model Management Subsystem uses a set of rules, also called Rules System, a central component of the DSS that consists of conditions-consequences complexes defined in DSS and the way they work effectively and pseudo-arbitrarily (as was mentioned at the PDSS). This module performs the operations of: selecting the rules, filtering them according to their applicability, choosing the control strategy and executing the rule [18]. The choosing strategies in executing the rules are [8]:
• the most specialized rule – which has the most conditioning;
• the most productive rule – which has the most effects;
• heuristic – which aims to achieve the most desired effects;
• determined on a trustworthy basis – when more trust is given to a particular rule.

The schema of this DSS subsystem is shown in Figure 5.

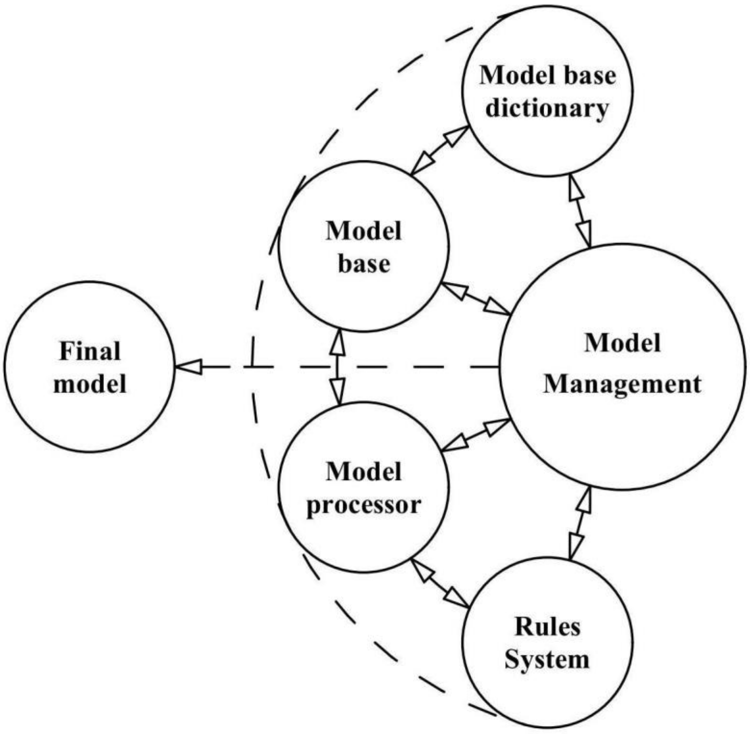

Figure 5. The components of the Model Management Subsystem

The User Dialog Management Subsystem

The transition of information between the DSS and the user set is done through the User Dialog Management Subsystem. The user interface (UI) must be as user-friendly as possible, because, through the graphical interface, the user contributes to presenting the problem, in the classic DSS, or sometimes to solving it, within the PDSS. The DSS provides the user with information about the decision-making process.

The elements of this subsystem are – see also [9],[14],[15]:
• the human-DSS dialogue management subassembly – the first element in front of the Data, Knowledge and the Models Management Subsystems, consisting of software tailored to the user typology and the typology of the information it transfers;
• the human language interpreter – takes the information received from humans, converts it into the DMS own language and vice versa (converts the user's DSS response into comprehensible language for the DMS);
• the graphical user interface – actually takes the input data received from the user and displays the output data using human-like (natural) language, assuring the Human-Computer bidirectional communication (interaction). Loredana Mocean has identified in[14] six types of communication that can take place between the man and the computer;
• hardware devices – consist of dedicated electronics produced and used in all means of human interaction with the DSS.

The complexity of the DSS increases with the integration into its subsystem of technologies that allow multimodal communication between the system and the human, that is, alongside the use of hardware devices, the use of handwriting, spontaneous natural human language, the acceptance and understanding of voice commands and providing by the DSS to the man of voice responses with natural language.

The schema of this DSS subsystem is shown in Figure 6.

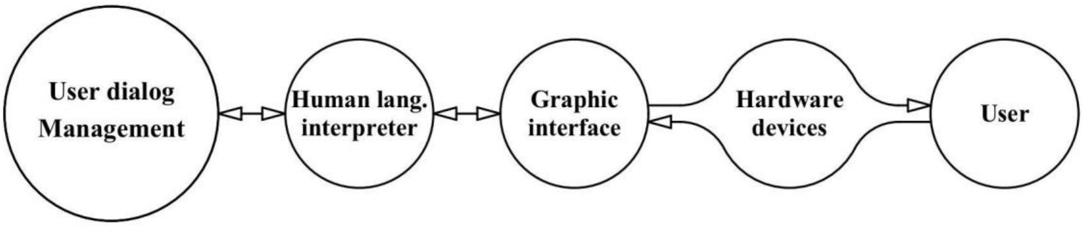

Figure 6. The components of the User Dialog Management Subsystem

The infrastructure

A major advantage of the DSS, as a computer system with a particular purpose, is that it can benefit and, therefore, integrate the current developments in the Information Technology.

The DSS's success is, for the moment, the ability to integrate World Wide Web technology over the Internet in a controlled and secure manner. This is done through the server-client architecture, while the *server* contains the DSS core with all its components less the UI [9], and including the sub-component of the Human-Language Processor for converting the human message into the system language. The *client* is dedicated to the UI and also includes the homologous component of the Human-Language Interpreter to perform the reverse transition.

The infrastructure of a DSS consists of the hardware and equipment used to carry out all the activities and processes involved in the DSS, to which we add the programming language that develops it, the one that chooses and builds the shell with the graphical user interface and the knowledge base. As a result of the increasing complexity of acquiring knowledge in the knowledge base of the DSS and the expert systems, it has developed the discipline Knowledge Engineering [8].

Due to the very high speed which Information Technology is evolving with, it is not relevant to provide a detailed overview of what it currently provides with regards to the Decision Support Systems. At the time of building a DSS, an investigation and absorption of available resources will be made.

5. Conclusions

The structures' aesthetics topic is a wide one and the criteria that apply to it vary a lot, so the means they may be gathered, assimilated and controlled. Given its proven necessity, the evaluation of the structures' aesthetics may be driven with the help of a complex framework that is the Decision Support System. The characteristics of the latter prove its usability and scalability in this field.

In the second part of this article are brought into attention the advantages that an Intelligent Decision Support System using the Fuzzy Logic add to our framework. The application of our proposal is shown in a separate paper called *The application of a software using fuzzy logic in the evaluation of the structures' aesthetics,* that comments the evaluation made on five structures by people from public, while the results are interpreted with an application developed in JAVA and using fuzzy logic elements.

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