Research Article

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# Interdisciplinary approach for simulation of starting points for optical and architectural design

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**Abstract:** Modern science becomes more complex day after day. Besides, there appeared many unpredictable links between different subjects, which we never expected to be connected. This is called 'interdisciplinary' science. For example, just occasionally we found common points in the simulation of the starting input for optical and architectural design, and moreover, we discovered a lot of similar procedures in both of them. Basing on the analysis of these two fields of knowledge, as well as using optical expert and architectural expert evaluations, we propose an approach to build a heuristic algorithm for computer aided design in these two fields. Later, we expect that it grows into a set of expert systems under the roof of artificial intelligence. We see in the near future a prospective of using new technology in design–building information modeling, which could be expanded from architectural design to optical design, etc. Besides, this is our first experience in this field. We consider that it is possible to widen it further to other subjects. The main ideas of this approach are presented.

**Keywords:** architectural design; artificial intelligence; expert system; heuristic algorithm; optical design.

## 1 Introduction

Once having a seminar with participants from different technical universities, we found out that some design processes in different fields look very similar.

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Another important statement is that to be successful in many technical fields, we need both science and art, talent and knowledge.

Technical and computer revolution gave us the information technologies as tools in any field. Information technologies play a role similar to mathematics in old times and give us a base and common approach in different fields.

About 40 years ago, mankind started to use artificial intelligence (AI) for solving many problems. Expert systems play a special role in this process.

An expert system is a computer-based system created to respond as a human expert in a given field. Expert systems are built on knowledge gathered from human experts, analogous to a database, and contain rules that are applied to solve a specific problem, for example, the selection of a starting point in optical design and architectural design, etc.

Expert systems are becoming popular in design as they increase the efficiency of any design process and make a designer free from routine procedures.

To create an expert system, we need a team of field experts, knowledge engineers, and programmers.

The goal is to 'explain' to a computer how to design an optical system (or a house).

When we design an optical system, we use optical elements (OEs) and their combination to get a really good operational optical system.

When we design a house, we use architectural elements and their combination to construct a house.

After the knowledge of an expert is formalized, heuristic algorithms are created. Software based on heuristic algorithms works independently on a design subject.

Having similar classifications, common language and common rules give us a chance to create an interdisciplinary expert system with a flexible structure applicable in different technical fields depending on the content of the database.

In this paper, we show two examples of expert systems for optical and architectural design.

The novelty of this approach is in interdisciplinary-based technologies and in the exchange idea of a heuristic algorithm between different fields of knowledge adding value to the whole system.

## 2 Expert system for design

The main question for any design is ‘How to start?’ or ‘What is the starting point?’

We propose an expert system, which answers these questions and produces a structural synthesis of starting points for optical (or architectural) design by means of combining optical (architectural) elements using rules elaborated by an expert in the field of optics (architecture).

A typical structure of an expert system [1] is presented in Figure 1.

For better understanding of the process of creating an expert system, we would like to discuss the function of each element in the structure above.

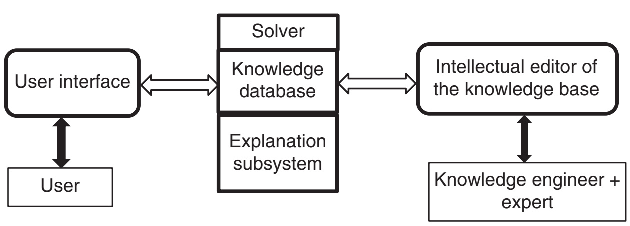


**Figure 1:** Expert systems’ structure.

*User interface* – a set of programs that implements the end user dialog with the expert system both at the stage of information input and when obtaining results.

*Knowledge base* – the core of the expert system, recorded on a machine medium in a form understandable to the expert and the user.

*Solver* – a program that simulates the course of expert reasoning on the basis of information available in the database.

*Explanation subsystem* – a program that allows the user to get the description of the whole process and all steps of the chain of conclusions. Developed explanation subsystems support other types of questions.

*Intelligent editor* – a program that provides the knowledge engineer the ability to create a database in an interactive mode. It includes a system of nested menus, templates of knowledge representation language, tips (‘help’ mode), and other service tools that facilitate work with the database.

In Figure 2, our approach to an expert system for design projects [2] is presented.

### 2.1 Classification

Classification is the base of any expert system. An example for a networking of two groups to create an expert system is shown in Figure 3.

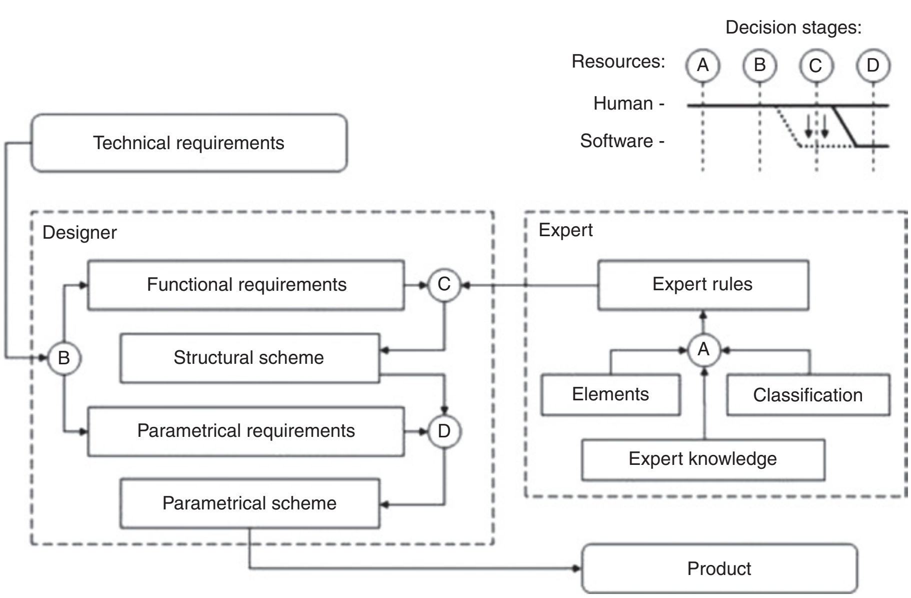


**Figure 2:** Proposed approach to expert system created for design projects.
Where A, B, C, D are the resources for the decision stages: A – studying technical and functional requirements (designer = user); B – input of classification/database, elements, expert rules; C – creating a structural scheme; D – creating a parametrical scheme. Every step is supported by special software.

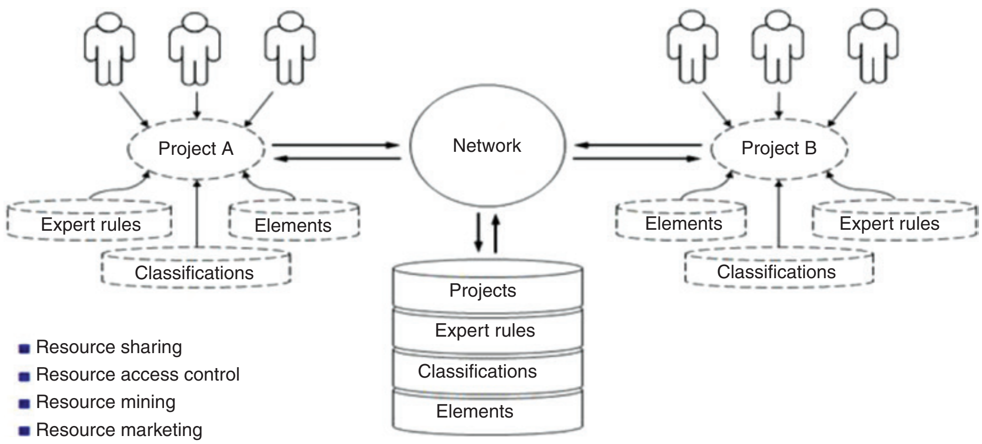


**Figure 3:** Networking vision of two groups working simultaneously on two design projects.

In our case, two groups are working simultaneously to solve two design problems [2]. The advantages of such an approach are resource sharing, access control to resources, its mining, and marketing.

'Project A' is an optical system design, and 'Project B' is a building design in architecture.

In the frames of our two design projects, we created two different classifications for optical and architectural design. We decided to have seven big classes of our technical specifications. They are presented in Table 1. One can see the similarity in the two design approaches. It means that when we design a system (no matter if it is optical or architectural), we have to start with the determination of the classes of the system under the design. These classes make a skeleton of our expert system. Its other important parts of are based on these classifications.

**Table 1:** Characteristics for optical and architectural designs.

| N | Characteristic | Optical (project A) | Architectural (project B) |
|---|---|---|---|
| 1 | J | Aperture speed | Building purpose |
| 2 | W | Field | Type of the building |
| 3 | F | Focal length | Fire resistance |
| 4 | L | Spectrum range | Landscape |
| 5 | Q | Image quality | Climate stability |
| 6 | S | Back focal distance | Number of floors |
| 7 | D | AS position | Service life |

Each characteristic is expressed in two ways (see Figure 2): generalized (introduced by a knowledge engineer) and technical (presented by an expert) [3].

Generalized characteristic shows the degree of the complexity (R) of the system, which is presented by the following equation:

$$R = J + W + F + L + Q + S + D$$

Each characteristic within the classification can take one of the three values, which we call *sub-classes* (see Figure 4):

1. 0 – 'poor, low, short …'
2. 1 – 'average, medium, standard
3. 2 – 'high, long …' (high image quality)

A certain combination of values for J, W, F, L, Q, S, D determines a certain class and subclass of a system.

Altogether, $3^7 = 2187$ combinations are possible; so depending on these values, we are able to design 2187 different classes of optical systems (or houses if we are working on architectural design).

Human experts established a link between technical and generalized values of each characteristic for each field.

These links are presented in Tables 2 (optical design) and 3 (architectural design).

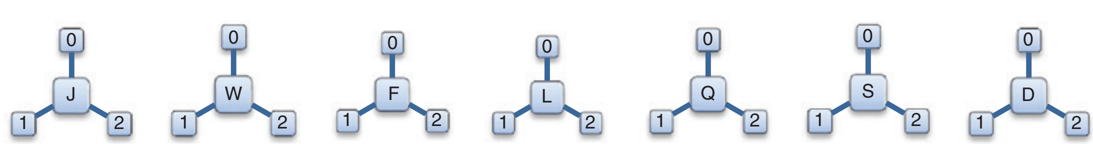


**Figure 4:** Explanation of subclasses and generalized characteristics.

**Table 2:** Generalized characteristics for simplest optical system.

| Characteristic | Generalized | Comment |
|---|---|---|
| J | 0 | Low aperture |
| W | 0 | Small field |
| F | 0 | Short focal length |
| L | 0 | Monochromatic |
| Q | 0 | Geometrically limited image quality |
| S | 0 | Short back focal distance |
| D | 0 | AS inside the system |

**Table 3:** Generalized characteristics for the most complex optical system.

| Characteristic | Value | Comments |
|---|---|---|
| J | 2 | Super fast |
| W | 2 | Wide linear field |
| F | 2 | Long focal length |
| L | 2 | UV spectral range |
| Q | 2 | Diffraction limited |
| S | 2 | Long back focal length |
| D | 0 | AS inside the system |

Generalized data is understandable for a computer and linked with technical values understandable for a designer.

In the case of optical design, the numbers ‘0’, ‘1’, ‘2’ presented in Figure 4 are symbols of the generalized characteristics of lenses, implicitly associated with the choice of the starting point of the optical system [4].

‘0’ – corresponds to the optical system with the value of technical characteristics, for which the simplest optical scheme is sufficient or similar in architectural design for which the simplest building is sufficient;

‘2’ – describes a characteristic of the lens, the scheme of which is the most complex and has the largest number of elements to achieve the required high technical characteristics or, in architectural design, it stands for the most complex building.

‘1’ – characterizes a system, which occupies an intermediate position on the complexity of the implementation between ‘0’ and ‘2’.

Let us consider four examples that show the range of classes of optical (Tables 2 and 3) and architectural systems (Tables 4 and 5) under the described classification.

Example 1. The generalized characteristics for a simplest optical system are presented in Table 2.

For optics – class ‘0000000’, this system has low aperture, small field angle lens with a short focal length, monochromatic, geometrical image quality, short back focal length, aperture stop (AS) inside the optical system.

**Table 4:** Generalized characteristics for simplest architectural system.

| Characteristic | Value | Comments |
|---|---|---|
| J | 0 | Living |
| W | 0 | Standard design |
| F | 0 | Combustible |
| L | 0 | Simple landscape around |
| Q | 0 | Standard climate conditions |
| S | 0 | One story |
| D | 0 | Temporary service life |

**Table 5:** Generalized characteristics for the most complex architectural system.

| Characteristic | Value | Comments |
|---|---|---|
| J | 2 | Industrial |
| W | 2 | Elite design |
| F | 2 | Fire resistant |
| L | 2 | Elite landscaping |
| Q | 2 | Cold climate |
| S | 2 | Multistory |
| D | 2 | Durable |

An architectural design for system ‘2222222’ is presented in Figure 5.

**Figure 5:** An architectural example for class ‘2222222’ [5, 6].

An expert considers this lens as a simple one; it has one to two elements (see Figure 6) [8].

In Table 3, the most complex optical system is presented (see Figure 7 with this lens drawing).

As a super fast, wide angular lens, with long focal length, chromatic aberrations in ‘2222220’ are corrected at an increased spectral range, having diffraction image quality, long back focal distance, and the AS is inside the optical system. An expert knows that it is a very complex system, which is called a photolithography lens (see Figure 7). The index of complexity of this system is R = 12.

Example 2. For the architectural design, the simplest class ‘0000000’ describes a living building with a standard design, not fire resistant (combustible), with simple landscape around, for standard climate conditions, one story, and temporary service life (see Table 4).

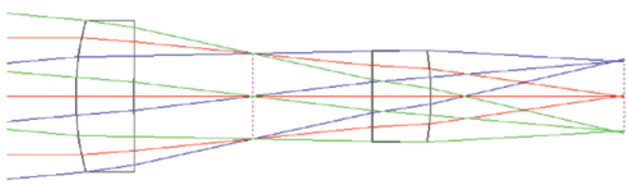

**Figure 6:** System ‘0000000’: ‘J’ = F5; ‘W’ = 10°; ‘F’ = 10 mm; ‘L’ = 546 nm; ‘Q’ – limited by geometrical aberrations; ‘S’ = 0.3S’; ‘D’ – inside, between, first, and second lenses [7].

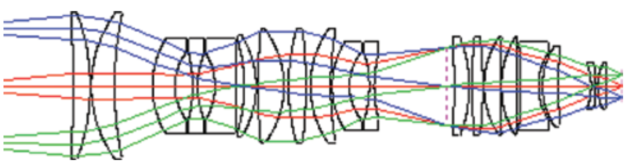

**Figure 7:** ‘J’ = F1.25; ‘W’ = 100 mm; ‘F’ = 2800 mm; ‘L’ = 300–346 nm; ‘Q’ – diffraction limited; ‘S’ = 0.7S; ‘D’ = 0, AS is inside the optical system [7].

**Figure 8:** System ‘0000000’ for architectural design. [http://proektabc.ru/, 6].

In Figure 8, we see an example of such a house.

In Table 5, we present the data for the most complex class ‘2222222’ in architectural design, which describes ‘J’ = 2 – a complex industrial building, ‘W’ = 2 – with elite design, ‘F’ = 2 – fire resistant, ‘L’ = 2 – with elite landscaping around, ‘Q’ = 2 – for cold climate conditions, ‘S’ = 2 – multi story, and ‘D’ = 2 – durable [9].

In Table 6, we show links between generalized and technical values in optical design.

In Table 7, links between generalized and technical values in architectural design are presented.

## 2.2 Databases

A database for an expert system for selecting a starting point for optical design uses the theory of OEs with well-known properties created by Professor Rusinov [10] and developed by his successors [1–4, 11, 12].

The offered approach is based on using, for lens design, the surfaces with well-known properties only, such as working at its aplanatic conjugates, concentric about the aperture or the chief ray, flat or near image surfaces.

The main feature of this method is the complete understanding of the functional purpose of each optical surface and every OE. So, the database of OEs consists of four types of elements, which differ by their function in the optical system.

The presented expert system allows to design centered refractive objectives, where the object is located at infinity and the image at final distance, a so-called ‘photographic objective’ type [13, 14].

**Table 6:** Link between generalized and technical values in optical design [1].

| Characteristic | Generalized value, sub-class | Technical value | Title of a lens class |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| *J* | «0» | $D/F' < 1:2.8$ | Low aperture |
| | «1» | $1:2.8 < D/F' < 1:1.5$ | Fast |
| | «2» | $1:1.5 < D/F'$ | Super fast |
| *W* | «0» | $2\omega < 15°$ | Small field |
| | «1» | $15° < 2\omega < 60°$ | Average field |
| | «2» | $2\omega > 60°$ | Wide field |
| *F* | «0» | $F' < 50$ мм | Short focal length |
| | «1» | 50 мм $< F' < 100$ мм | Medium focal length |
| | «2» | $F' > 100$ мм | Long focal length |
| *L* | «0» | $(\lambda_2 - \lambda_1) < 100$ нм | Monochromatic |
| | «1» | $10 < (\lambda_2 - \lambda_1) < 210$ нм | Achromatic |
| | «2» | $(\lambda_2 - \lambda_1) > 210$ нм | Apochromatic |
| *Q* | «0» | $D_{ba} > 5D_A$ | Geometrically limited image quality |
| | «1» | $2D_A < D_{ba} < 5D_A$ | Average image quality |
| | «2» | $D_{ba} > 2D_A$ | Diffraction limited image quality |
| *S* | «0» | $S' < F'$ | Short back focal distance |
| | «1» | $0.5F' < S' < F'$ | Average back focal distance |
| | «2» | $S' > F'$ | Long back focal distance |
| *D* | «0» | AS is inside optical system | |
| | «1» | AS is behind optical system | |
| | «2» | AS is in front of optical system | |

**Table 7:** Links between generalized and technical values in architectural design.

| Class | Sub-class | Generalized | Technical, source – Russian industrial standards |
|---|---|---|---|
| J | 0 | Living | Customer request |
| | 1 | Public | Customer request |
| | 2 | Industrial | Customer request |
| W | 0 | Standard | Wooden |
| | 1 | Improved | Panel |
| | 2 | Elite | Brick |
| F | 0 | Combustible | <1400 MJ*m$^2$ |
| | 1 | Nonflammable | 1400 < F < 2200 MJ*m$^2$ |
| | 2 | Fireproof | F > 2200 MJ*m$^2$ |
| L | 0 | Not improved | L < 100 m$^2$ |
| | 1 | Standard improvement | 100 < L < 1000 m$^2$ |
| | 2 | Elite landscaping | L > 1000 m$^2$ |
| Q | 0 | Standard | −10 < Q < 20 |
| | 1 | Hot climate | Q > 20 |
| | 2 | Cold climate | Q < −10 |
| S | 0 | One story | 1 |
| | 1 | Medium rise | S < 10 |
| | 2 | Multistory | S > 10 |
| D | 0 | Temporary | <5 |
| | 1 | Standard | 5 < D < 25 |
| | 2 | Durable | D > 25 |

Comments: J, customer request; W, building material; F, specific fire load on the site; L, the area of green space; Q, temperature °C; S, number of floors; D, years of life.

**Table 8:** Content of databases.

| N of an element | Elements in optical design | | | Elements in architectural design | | |
|---|---|---|---|---|---|---|
| | Type | | Quantity | Type | | Quantity |
| 1 | Basic | B | 6 | Foundation | FO | 4 |
| 2 | Correction | K | 8 | Floor | FL | 6 |
| 3 | Fast | C | 5 | Roof | RO | 6 |
| 4 | Wide angular | S | 6 | Wall | WA | 6 |
| 5 | Customer element | – | – | Window | WI | 6 |
| 6 | | | | Door | DO | 6 |
| 7 | | | | Customer element | – | – |

The expert system for architectural design allows to design buildings for living, public, and industrial purposes. Its database contains architectural and industrial standards used in the Russian Federation.

The database used for optical or architectural design is given in Table 8.

Databases for optical and architectural designs are constructed on open-access principles; other elements

**Table 9:** OE database.

| N of element | Basic | Correction | Fast | Wide angular |
|---|---|---|---|---|
| 1 | B(ap) | K(ii) | .C(pa) | S(0p) |
| 2 | B(pa) | K(i0) | .C(p0) | S(pp) |
| 3 | B(p0) | K(0i) | .C(pp) | S(ap) |
| 4 | B(pp) | K(pa) | .C(p0) | S(pa) |
| 5 | B(p0) | K(pp) | .C(pi) | S(op + pa) |
| 6 | B(pi) | K(aa) | | S(op + pp) |
| 7 | | K(0p) | | |
| 8 | | K(vv) | | |
| MORE | . | . | | |

and additional selection rules could be added into these expert systems. We call them 'customer elements'. To include customer elements into the database, experts have to determine selection rules for them and indices of applicability in the expert system.

In Figure 5, an expert system constructed for design is presented. It is used for optical or architectural design depending on the database we use.

A database for optical design is presented in Tables 8 and 9, where B, K, C, and S are elements types:

1. *'Basic' elements (B)* produce an optical power.
2. *'Correction' elements (K)* corrects residual aberrations of other elements.
3. *'Fast' elements (C)* are used for developing the aperture of an optical system. They have only positive optical power, but in distinction to the basic elements, they work only from the finite distance; so, they are always located after the basic element.
4. *'Wide angular' elements (S)* are used for developing the field angle in an OS. They are negative or afocal, and always located infront of the OS, before the basic element, correction element could be located between them.

Surface types are shown enclosed in parentheses (…) in Table 9. Two surfaces are enough for one lens element, but if we have more elements in parentheses – lenses could be cemented or an element has two lenses in it, for example, S(op + pp) means that a wide angular element consisting of two lenses, first is formed from two surfaces: flat and concentric about the center of the AS and a second lens has a bi-concentric meniscus with both surfaces concentric about the chief ray.

In Table 10, we see architectural elements, which fit to six classes (groups). The further classification in the group describes different types of every element inside one group. The selection rules are based on the Russian industrial standards of architectural design. Every element has an index of applicability determined by an architectural expert.

**Table 10:** Database for elements in architectural design.

| N | Foundation (FO) | Floor (FL) | Wall (WA) | Roof (RO) | Window (WI) | Door (DO) |
|---|---|---|---|---|---|---|
| 1 | FO1-shallow | FL1-timber | WA1-load bearing | RO1-gable | WI1-double hung | DO1-french |
| 2 | FO2-strip | FL2-laminate | WA2-precast concrete | RO2-hip | WI2-casement | DO2-bi-folding |
| 3 | FO3-raft (mat) | FL3-vinyl | WA3-retaining | RO3-mansard | WI3-awning | DO3-pivoting |
| 4 | FO4-pile | FL4-bamboo | WA4-masonry | RO4-flat | WI4-picture | DO4-sliding |
| 5 | | FL5-cork | WA5-cavity | RO5-gambrel | WI5-slider | DO5-revolving |
| 6 | | FL6-tile | WA6-compartment | RO6-saddle | WI6-stationary | DO6-automatic |

## 2.3 Algorithm of structural synthesis

An algorithm of structural synthesis is the base of the expert system, which is presented in Figure 9.

1. The user sets the values of the indicators of the class of the desired system.
2. The user selects the thresholds for the item and schema applicability indexes. The selection of threshold values is carried out in order to reduce the number of synthesized schemes.
3. Using the previously described database, the original lists of elements are generated programmatically. Then, with the help of expert rules, the index of applicability of each element in the class under consideration is determined.
4. From the generated lists, elements with an index of applicability below the specified threshold are selected programmatically, and the remaining elements are sorted in descending order of the index of applicability. This makes it possible to obtain combinations with high total indices of applicability at the early stages of synthesis.
5. In accordance with the previously described synthesis formula, the generation of structural schemes is carried out. Different combinations are analyzed programmatically.
6. This is the how the expert system works.
7. If we take elements from the database in Table 9, we design a structural optical scheme.
8. If we use elements from the database in Table 10, we design an architectural scheme.
9. The expert system ‘understands’ and takes the corresponding selection rules for each project.
10. The result for the optical design expert system is a synthesis formula where types of OEs and surfaces are listed.
11. The result for the architectural design is a list of architectural elements and their descriptions.

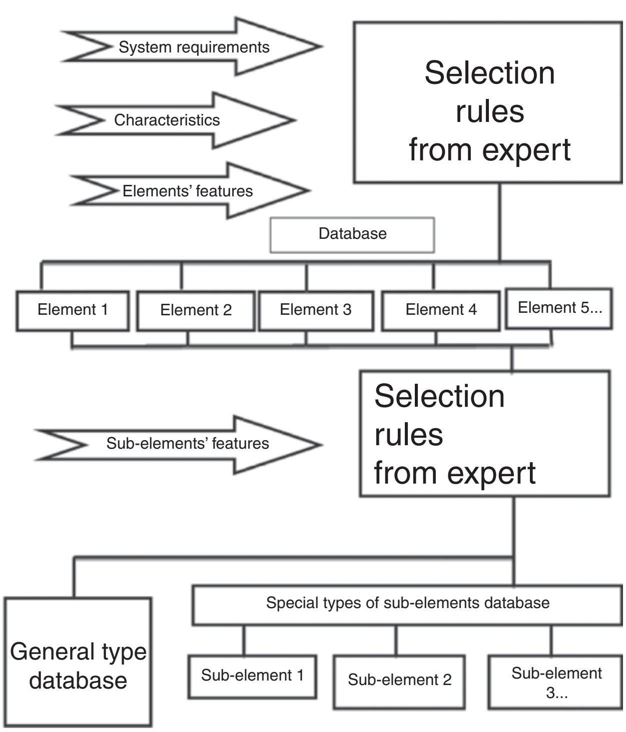


**Figure 9:** Expert system for structural synthesis.

## 2.4 Selection rules

The procedures of selecting the surfaces’ types for the OE construction and the selecting of the OE, themselves, for structural schemes are done using the finite set of selection rules and are called *structural synthesis*. The formula for structural synthesis contains the type, the quantity, and the arrangement of the OE (see also Figure 10).

In Figure 10A, the sequence of the OEs in the structural scheme is presented. We start any optical design with a selection of a basic element. Next, we analyze the image quality and add the correction elements if necessary. The quantity and types of elements depend on the type and value of the aberrations to be corrected.

If generalized characteristic ‘J’ is non-zero – we have to develop the aperture and design a fast lens. In this case, we add ‘fast’ elements.

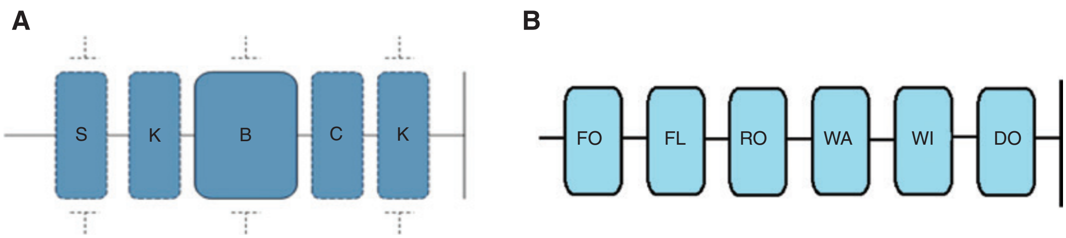


**Figure 10:** Recommended combination of OEs (A) and architectural elements (B).
(A) Basic element always presents in optical system (shown in solid line), other elements" S, K, C are shown in dotted lines as they may absent in the recommended combination. (B) All elements are necessary for architectural design, so, all of them are shown in solid lines.

If generalized characteristic 'W' is non-zero – we have to develop the field and design a wide angular lens. In this case we add 'wide angular' elements.

In Figure 10B, the recommended combination of architectural elements is presented. The difference of combinations (A) and (B) is that the number of the OEs in an optical structural scheme is variable, and in architectural design, it is constant.

Optical experts use their experience in the field of optical design. To transfer it into the shape that fits the expert system, the fuzzy logic was used. In total, we used about 200 selection rules.

We call it heuristic algorithms. We present some examples on how to select types and quantity of OE. In Figure 10, the recommended combination of the OE is given. We always need basic and correction elements, but if $W=0$, we do not need elements to develop the field; if $J=0$, we do not need the OE to develop the aperture.

An example of selection rules for optical components proposed by an optical expert:

Condition to select the basic element:

For B(pp): $(D\neq 0)\&(S\neq 2)\&(J\neq 2)=(W=2)\&(F=0)$, for B(pa): $(D\neq 2)\&(J\neq 2)=(W\neq 2)$, etc.

The same logic is used to select the other types of elements: for S(pp): $(D=2)\&(W\neq 0)$ and so on. The system also checks for possible neighborhood of the elements in the optical system.

The recommended combinations of architectural elements come from an architectural expert and are similar to optical selection rules.

In Figure 11, we see a resulting structure for an objective – we call it the formula of structural synthesis. In

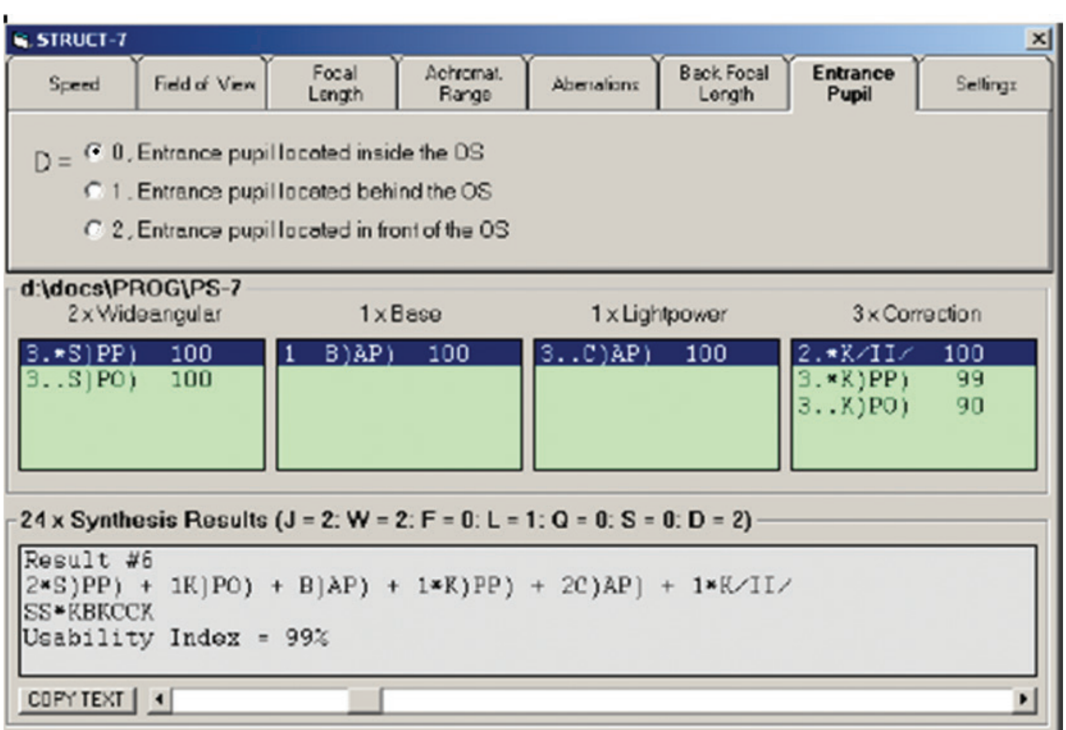


**Figure 11:** Example of software STRUCT-7, a version of expert system for starting point selection in optical design.

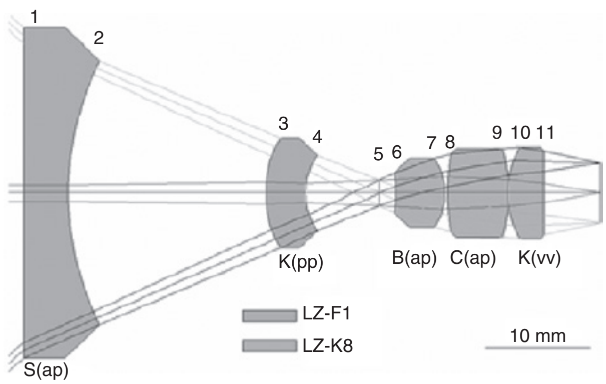


**Figure 12:** Example of objective design with the software STRUCT 7.

Figure 10, it is called result #6, where: 'J' = 2 – aperture is F2; 'W' = 2 – 2w = 82°; 'F' = 0; f' = 3 mm; 'L' = 1 – expanded visual spectral range; 'Q' = 0 – image quality is limited by geometrical aberrations; 'S' = 2 – back focal length is bigger than focal length; 'D' = 0 – AS is inside the optical system. The index of complexity is R = 7 [1, 7, 11].

In Figure 12:

1. S(ap) – wide-angular lens with first aplanatic and second surface concentric about the chief ray;
2. K(pp) – correction element bi-concentric meniscus concentric about the chief ray;
3. B(ap) – basic element with first aplanatic and second surface concentric about the chief ray;
4. C(ap) – fast element with first aplanatic and second surface concentric about the chief ray;
5. K(vv) – correction element with two surfaces concentric to the image center.

Positive lenses with surfaces 6 + 7, 8 + 9, 10 + 11 are made from Russian crown glass LZ-K8, similar to the BK7 glass from the Schott glass catalog; negative lenses with surfaces 1 + 2, 3 + 4 are made from Russian flint glass LZ-F1, similar to the F2 glass from the Schott glass catalog (S. I. Vavilov, St. Petersburg, Russia). AS is located on surface 5.

### 2.5 Example of algorithm implementation for optical design

An example of a design with STRUCT 7 after structural synthesis following parametrical synthesis is presented in Figure 11 [2, 4, 15].

Until now, there is no special software for architectural design similar to the software STRUCT 7 for optical design. It is now at the step of heuristic algorithm development.

## 3 Perspectives in using information modeling in expert systems for optical and architectural design

The expert system is a program based on the expert knowledge and skills in the form that allows the system to give reasonable advice or make a reasonable decision about data-processing function. In addition, the system explains its line of reasoning on demand in an understandable way. The starting points for optical and architectural design, together with the explanation of the reason of selection, are ensured by the method of programming using the expert rules [1–4, 7, 11, 12].

An expert system created to assist in any design processes has similar nature and could be constructed using the same or equal structure.

The interdisciplinary approach saves time for programming a set of expert systems.

## 4 Conclusions

This publication is the first attempt to comprehend, systematize, and formalize the experience of a number of domestic and foreign developers of optical and architectural systems in terms of the process of choosing starting points. Heuristic algorithms underlying the creation of the necessary theory of choice of the starting point were obtained as a result of active interaction of experts and knowledge engineers, who formed the initiative group of this innovative project.

The first step is the most difficult. We understand that we have a lot of work ahead of us to formalize the heuristic rules for the design of other classes of optical systems, such as telescopic, projection, etc., but the general rules of the layout remain unnamed – the design always begins 'from the bottom up' – with the choice of the base element, then other necessary elements are introduced into the system: corrective elements, elements for the development of the field, and aperture. The system is consistently developed; all elements are installed in accordance with their functional purpose, which avoids the appearance of 'extra' elements in the optical scheme. Each change made by the program is commented and explained that can be effectively used in the educational process.

A similar work is performed by the group of expert system for architectural design. We are looking forward to attract more experts and engineers to continue our interdisciplinary research.

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