

**SOFTWARE SYSTEM FOR NIGHT VISION DEVICES DESIGN
BY REASONABLE COMBINATORIAL CHOICE**

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ABSTRACT. A Web-based software system for night vision devices (NVD) design is presented. The reasonable combinatorial choice is used for the design process modeling. NVD design process modelling involves choice of the NVD modules (objective, image intensifier tube, ocular) taking into account their dependencies and restrictions and the external surveillance conditions. The system calculates the device working ranges (detection, recognition, and identification), the NVD magnification and NVD optoelectronic channel weight and price. If the calculated parameters are not what are required the designer can choose another modules combination and repeat the calculations. The implemented reasonable combinatorial choice gives the designer opportunity to enter desired limits for some parameters and the system automatically chooses the possible modules combination to satisfy them. The system is built as a Web-based application and runs in browser environment with JavaScript features regardless of the operating system installed on a client side. It can be used concurrently and independently from any Internet-user since all data and calculated NVD parameters are loaded and kept on the user computer and are not available for the other users. Using the developed software system as a virtual NVD design tool reduces the design costs for multiple prototypes building and testing.

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1. INTRODUCTION

There exist many application areas which can benefit of the mathematical modelling and the technological development of the modern computers and the engineering design is among them [1, 2, 3, 4]. The engineering design is as much art as science and there can be a wide choice of possible solutions, or possible variations of one solution. Nevertheless, any attempt to help the designer by automating some of his hard work - performing complex calculations, making some logical and reasonable choices, visualizing the results etc., would be helpful. Even simple computer added design (CAD) systems could increase the design process efficiency and decrease the design time and money costs.

The night vision devices (NVD) have received an increasing popularity recently [5, 6] The application areas of the NVD are extended not only to military but to civil applications too. There exist sets of NVD modules with different parameters, quality and price which can be used to develop NVD satisfying different user requirements. In practice, designing of the NVD is mostly intuitive "trial and errors" process entrusted to highly experienced specialists. It includes calculations for the modules dependencies, choosing and buying proper modules, developing some mechanic construction and prototype building and testing. If the design goals are not met the whole design process should be repeated. That kind of design process can be modeled and simulated in computer environment to help the increasing of the design efficiency. To model and simulate properly the NVD design process some theoretical bases should be used. Some possible to use theoretical developments for the NVD design modelling are described in [7, 8, 9, 10, 11].

The current paper presents the realization of the so called "reasonable choice method" for the NVD design [9] in the software system "NVDpro". The implementation of the reasonable choice method assists the designer to try different modules combinations supplying him with some theoretical estimation of the NVD parameters. It is known that the NVD optoelectronic channel is the most important subsystem of the NVD and its parameters define the most of the NVD parameters [10]. A software system for the NVD optoelectronic channel design by reasonable choice of its modules (objective, image intensifier tube and ocular) can be used as a NVD CAD tool.

2. ALGORITHMIC REALIZATION OF THE REASONABLE CHOICE METHOD

The reasonable combinatorial choice for the NVD design is described in details in [9]. It simulates the NVD design process in the computer environment and supports the designer to find a good (reasonable) combination of NVD modules taking into account the design restrictions, user requirements and given surveillance external conditions. The generalized diagram of its algorithmic implementation in software system "NVDpro" is shown on Fig. 1.

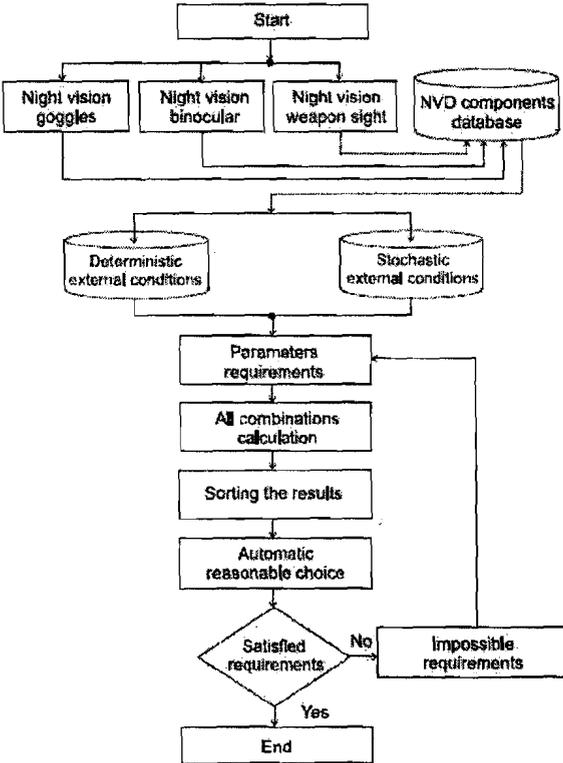


Figure 1: Generalized algorithmic implementation of the reasonable choice method for NVD design

The stages of choosing of the NVD type, of the external surveillance conditions values and the NVD modules are straightforward and easy to implement while the stages of the results calculation and the reasonable choice realization need developing of specific algorithms.

Practical experience shows the most essential parameters for the NVD functionality are working range, weight and price. Those parameters of the NVD optoelectronic channel are dominating for the corresponding NVD parameters and were chosen to be calculated and shown as preliminary theoretical estimation of the NVD quality.

The main theoretical base for the theoretical NVD working range estimation is the formula developed in [7, 10]:

$$R = \sqrt{\frac{0.07EK\tau_a A_{ob} D_{in} f_{ob} \tau_{ob} S \delta}{M \Phi_{min}}} [m] \quad (1)$$

where: E - ambient light illumination in lx , K - contrast, τ_a, τ_{ob} - atmosphere and objective transmittance, A_{ob} - target area in m^2 , D_{in} - diameter of the objective inlet pupil in m , f_{ob} - objective focal length in mm , S - IIT luminous sensitivity in A/lm , δ - IIT limiting resolution in lp/mm , M - IIT signal to noise ratio and Φ_{min} - IIT photocathode limiting light flow in lm .

Using some modifications of the formula [1, 4] three types of the NVD working ranges are calculated - detection, recognition and identification ranges. The designer can use the theoretical estimation of the NVD working ranges to evaluate them beforehand until the results became close enough to the desired values. That decreases the number of the needed prototypes to build and test.

The weight and price of the NVD optoelectronic channel are calculated by summarizing the weight and price of the chosen modules - objective, image intensifier tube and ocular. The weight and price of the designed device should include also the weight and price of the device mechanics and the power supply but it have been already pointed out the optoelectronic channel weight and price are indicative enough to estimate how efficient is the NVD design.

Another practically important NVD parameter depending on the objective and ocular choice is the NVD magnification α . It is calculated by focus ranges of the objective f_{ob} and ocular f_{oc} [4] as:

$$\frac{f_{ob}}{f_{oc}} = \alpha \quad (2)$$

If the chosen IIT has its own magnification β , the overall device magnification is calculated by:

$$\frac{f_{ob}}{f_{oc}}\beta = \alpha \geq 1 \quad (3)$$

For the night vision goggles the magnification $\alpha = 1$ and for the other NVD types - binoculars and weapon sights $\alpha > 1$ [4]. The existing magnification relation between objective and ocular focus ranges should be taken into account when the NVD modules databases are created. For example, when night vision goggles are designed the objective and ocular reasonable choices should be feasible only for the modules with $f_{ob} = f_{oc}$. For night vision binoculars and weapon sights the reasonable objective and ocular choices should comply with the requested value of the magnification α .

Another dependence consideration to take into account is between the IIT's screen diameter D_{IIT} and the ocular field of view w_{oc} :

$$2\sin\frac{w_{oc}}{2} \geq D_{IIT} \quad (4)$$

providing the effective usage of the IIT output image.

All of those existing dependences between NVD modules are implemented algorithmically in the system "NVDpro". Some graphical visualization example of the NVD modules relations is shown on Fig. 2.

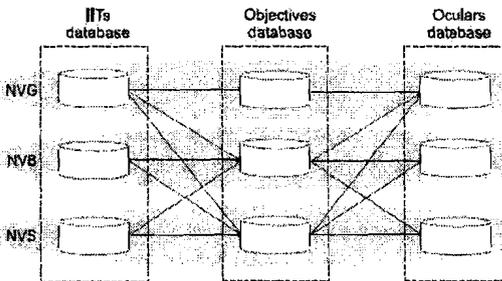


Figure 2: NVD modules mutual dependences

The core idea of the reasonable choice method is the automatic choice of the feasible NVD modules combination when some requirements for the NVD

operational characteristics are limited by the designer. The "NVDpro" system gives the designer the possibility to enter some preferred boundaries for the working ranges, weight, price and magnification.

The algorithmic realization of the automatic modules choice is based on calculating of the results for all possible modules combinations taking into account the existing dependences between them. Then the resulted arrays are sorted in increased order. For the satisfaction of the NVD working ranges (or magnification) desired value a search starts from the beginning of the relevant sorted array until a value greater or equal to the given one is found (Fig. 3a). If the desired value is for weight or price the search starts in the opposite direction - from the largest value until a smaller or equal value is found (Fig. 3b).

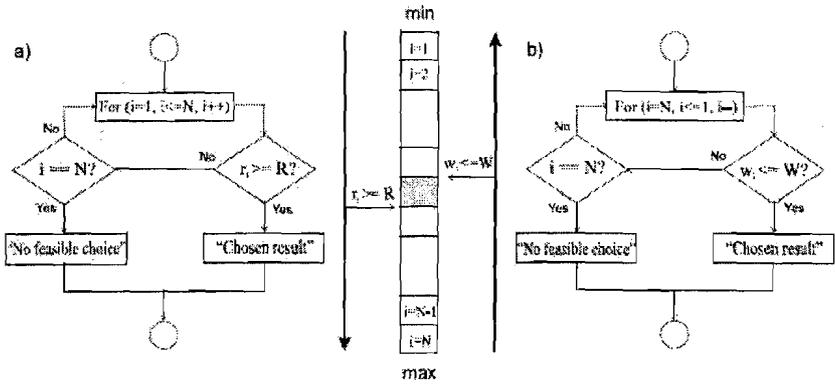


Figure 3: Algorithmic realizations of the automatic reasonable choice a) Working ranges and magnification choice, b) Weight and price choice

The modules combination found as a result of the reasonable choice is used to calculate the optoelectronic channel parameters. If the search is unsuccessful i.e. there is no feasible modules combination a proper message is shown.

Because there is no objective function used and no optimization task is solved the results of the reasonable choice method could not be defined as optimal but are "reasonable" according to the designer preferences.

3. NVDPRO DESCRIPTION

The main screen of the system "NVDpro" is shown on Fig. 4.

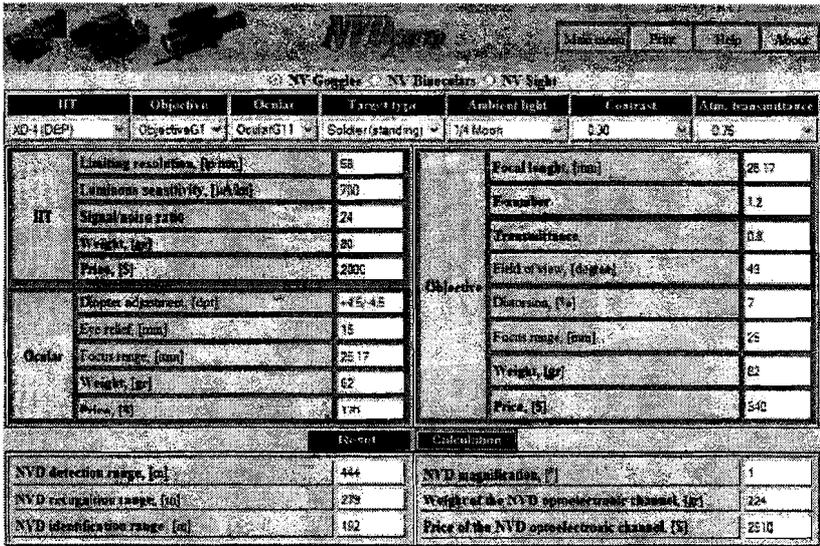


Figure 4: "NVDpro" main screen

The NVD design starts with choosing of the NVD type by means of so called "radio buttons". Then the designer chooses the main optoelectronics channel modules (IIT, objective, ocular) and the external surveillance conditions from the implemented databases by means of the "drop-down lists" (Fig. 5).

The external surveillance conditions - ambient light, contrast between background and target and atmospheric transmittance could have given deterministic values known for the expected geographic, climatic etc. conditions or the mathematical expectation values from their probabilities distributions. As a result of the designer choice the IIT, objective and ocular parameters fields are loaded with their values. The NVD operational characteristics (detection, recognition and identification ranges, magnification, weight and price) are calculated after pressing the button "calculation". If the results calculated do not

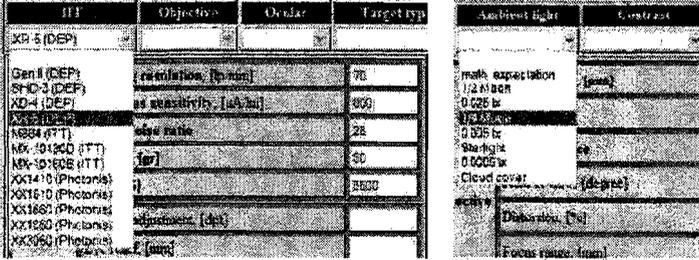


Figure 5: Choosing by "drop-down lists"

meet the given requirements the designer has two alternatives. The first one is to make a new choice of some of the modules and to repeat the overall iterative process as many times as it is needed until the design goals are met. The second alternative gives the designer option to define preferred boundaries for some device parameter. That alternative uses the "reasonable choice" [9], i.e. automatic choice of modules combination to satisfy the designer preferences. Then pressing of the button "calculation" activates the automatic reasonable choice and a combination of modules to comply with the entered values is found or if that is impossible a proper message is shown. The designer can use these two alternatives on wish. The NVD design by system "NVDpro" is essentially an iterative computer simulation of the traditional design process extended with automatic NVD modules choice to satisfy some designer requirements.

The buttons "reset", "help", "print", "about" are self-explanatory as typical for the most software systems.

An extra option implemented in the system "NVDpro" is the possibility to edit some of the parameters data fields for the optoelectronic channel modules - IIT, objective and ocular. That possibility is useful when a difference exists from the stored database parameters and the real parameters data of the available modules (sometimes catalogue data differs from the data of the used modules). That possibility could be used also as analysis tool to define most appropriate parameters for custom made modules to get the expected NVD operational characteristics.

The first version of the software system "NVDpro" is realized as Web-based application with internal database and is stored on the server-side. The system

is accessible through Internet by any JavaScript capable browser. Realizing it as Web-based application [12] has the advantage to be easily updated and maintained as a single copy without distributing and installing software on the client computers. Another advantage is the support from the standard browsers and the ability to perform as specified regardless of the operating system installed on the clients computers. User interface and the dynamic operations are accomplished by JavaScript [13] as it is one of the standard languages supported by all of the popular Internet-browsers. For security reasons all operations and calculations results stay locked on the client side and are not accessible for the other users of the system.

4. CONCLUSION

The paper describes the algorithmic realization and software implementation of the "reasonable choice method" [9] for the NVD design in a Web-based system "NVDpro". The system is designed as a "decision maker" tool for the NVD optoelectronic channel modules choice and for calculating of the basic NVD operational characteristics. Using the system gives a preliminary theoretical estimation of the designed NVD optoelectronic channel parameters - detection, recognition and identification ranges, magnification, weight and price. The theoretical estimation for the NVD operational characteristics helps to avoid the multiple prototypes building and laboratory or field testing for the conformity of the design requirements increasing the design process efficiency and decreasing the design time and costs.

The software system "NVDpro" is developed as a Web-based application - stored, updated and maintained on the server-side and is accessible on the client-side through Internet by any JavaScript capable browser. The work sessions data and results are stored on the client-side and are not accessible to the other system users.

The system has open architecture that allows future functional extensions, for example - user editing of the modules databases, electrical battery power supply elements choice and the relevant device operational time calculation, considering mechanics construction, etc.

The first version of the system prototype was tested in the practice of the Bulgarian company "ElkoE" and has proven its applicability.

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