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INTERACTIVE DESIGN OF MACHINE ELEMENTS IN UNCERTAINTY AND UNREPEATABILITY

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Summary

The article describes the development of fundamentals of machine elements and assemblies design processes automation using artificial intelligence, and descriptions of structural elements' features in a natural language. Realization of those processes is in conditions of uncertainty and with non-repeatable processes. The aim of the research is to develop the basis for new design processes of higher level of automation, and object approach to problems and application of voice communication between the design engineer and data processing systems. In the proposed interactive automated design systems, computational artificial intelligence methods allow communication by speech and handwriting, resulting in analyses of design engineer's messages, analyses of constructions, encoding and assessments of constructions, CAD system controlling and visualizations. The system is equipped with several adaptive intelligent layers for human biometric identification, recognition of speech and handwriting, recognition of words, analyses and recognition of messages, enabling interpretation of messages, and assessments of human reactions.

Keywords: interactive machine design, human-machine interaction, intelligent CAD, automated design system

Interaktywne projektowanie elementów maszyn w warunkach niepewności i niepowtarzalności

Streszczenie

W artykule przedstawiono opracowane podstawy automatyzacji procesów interaktywnego projektowania elementów i zespołów maszyn z zastosowaniem sztucznej inteligencji oraz opisu cech elementów w języku naturalnym. Realizacja tych procesów następuje w warunkach niepewności i niepowtarzalności zadań. Celem prowadzonych badań jest opracowanie podstaw nowych procesów projektowania o wyższym poziomie automatyzacji, obiektowym ujęciu problemów i wykorzystaniu głosowej komunikacji projektanta oraz systemu przetwarzania danych. Metody inteligencji obliczeniowej w proponowanym interaktywnym systemie zautomatyzowanego projektowania pozwalają na komunikację za pośrednictwem mowy i pisma odręcznego, analizę znaczenia komunikatów inżyniera projektanta, analizę konstrukcji, ocenę i kodowanie konstrukcji, kontrolę systemu CAD i wizualizację. System jest wyposażony w inteligentne, adaptacyjne warstwy służące do identyfikacji biometrycznej, rozpoznawania mowy i pisma, rozpoznawania wyrazów, analizy i rozpoznawania komunikatów, analizy znaczenia komunikatów oraz oceny reakcji projektanta.

Słowa kluczowe: interaktywne projektowanie maszyn, interakcja człowiek-maszyna, inteligentny CAD, zautomatyzowany system do projektowania

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1. Introduction

The presented research involves the development of complex fundamentals of building intelligent interactive systems [1] for design of machine elements and assemblies on the basis of its features described in a natural language. The scientific aim of the research is to develop the bases of design processes (Fig. 1, 2) featuring the higher level of automation, objectual approach to problems and application of voice communication between design engineers and the data processing system. The comparison of the proposed new automated designing system with the present system of realization of designing tasks is presented in Fig. 3.

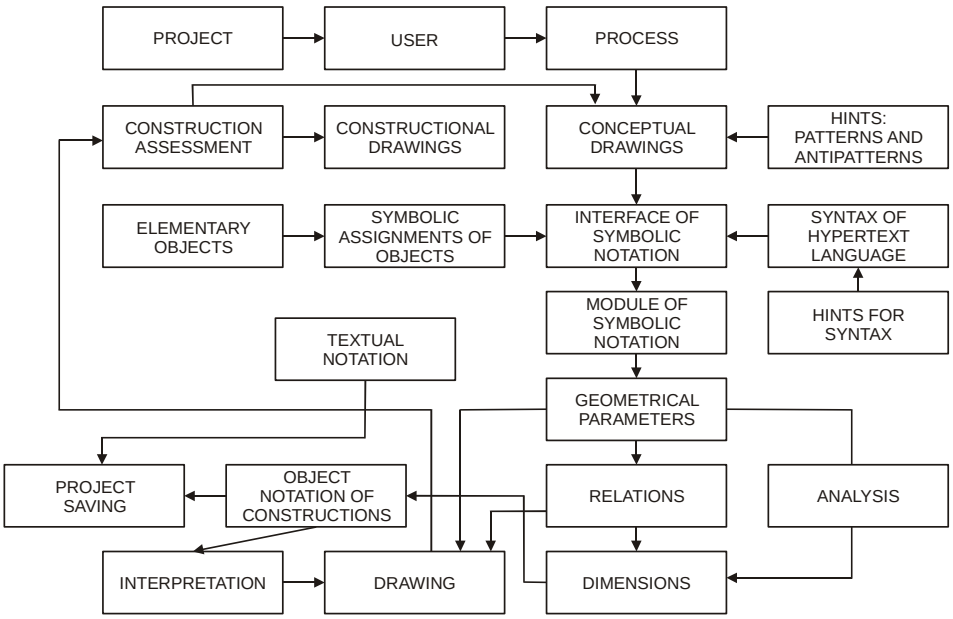

Fig. 1. Concept of automated design of machine elements and assemblies

The design and implementation of intelligent interactive automated systems for design is an important field of research. In these systems, a natural language interface using speech and handwriting is ideal because it is the most natural, flexible, efficient, and economical form of human communication [1, 2]. This concept proposes a novel approach to intelligent interactive automated systems for design of machine elements and assemblies, with particular emphasis on their ability to be truly flexible, adaptive, human error-tolerant, and supportive both of design engineers and intelligent agents.

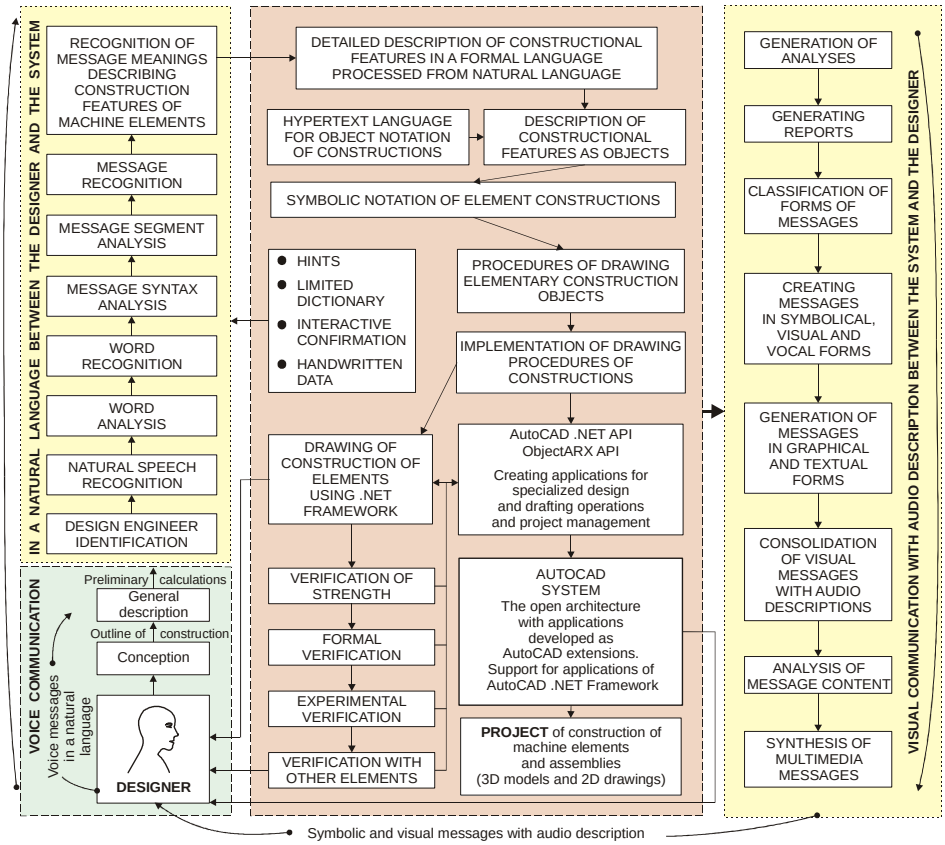

Fig. 2. Concept of interactive design of machine elements and assemblies

Application of intelligent interactive systems for design machine elements and assemblies using a natural language offers many advantages. It ensures robustness against design engineer errors and efficient supervision of machine design processes with adjustable level of automated supervision. Natural language interfaces also improve the cooperation between a design engineer and a design system in respect to the richness of communication. Further, intelligent interaction allows for higher organization level of complex design processes, which is significant for their creativeness and efficiency. Design process decision and optimization systems can be remote elements of design processes.

The design of that intelligent system can be considered as an attempt to create a standard intelligent interactive automated system for design processes using natural language communication. It is very significant for the development of new effective and flexible designing methods. It can also contribute for increase of efficiency and decrease of costs of designing processes. This designing system provides an innovative solution allowing for more complete advantages of modern manufacturing processes [3, 4] nowadays.

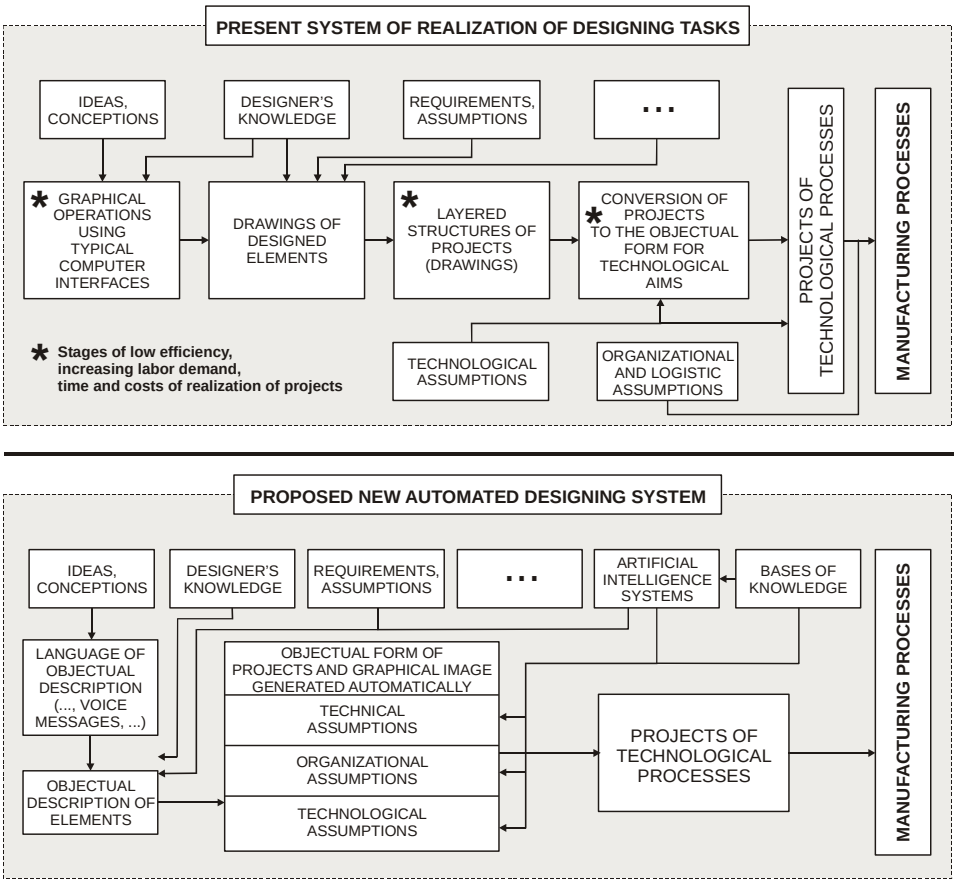

Fig. 3. Comparison of the proposed automated designing system with the present system of realization of designing tasks

In the design many advanced methods for problem solving and task fulfillment are used, in which the designer's explicit and implicit knowledge and skills are required for determination of product features to be created. The product features will be the outcome of many complex processes and actions [5-8], and will be assessed by the user in various operational conditions and various technical states. The novelty of the proposed system also consists of the development of a new system of symbolic notations of structure features concepts and notation language, methods of archiving and processing of construction description data (object oriented language for construction).

At the Koszalin University of Technology, taking advantage of the own developed solutions in the range of voice communication between users and technical devices, with the use of artificial intelligence, the research went on to be carried out concerning the development of complex fundamentals of building new

intelligent interactive systems for design of machine elements and assemblies on the basis of its features described in a natural language.

2. The State of the Art

The most important disadvantages of the present systems for creating construction notation can include:

- Creation of constructions through executions of graphical operations, with the use of slow communication interfaces, in the form of a keyboard, tablet and mouse, on elementary components of the types of lines and graphic symbols.
- Drawing is still excessively taking part in imposing the engineer designer's thinking processes.
- Completing and processing of data occurs in layers, which contain graphical symbols of particular types. Because of that fact, it is difficult to take advantages of objectual treatment of geometrical components of a particular object, e.g. particular grade of designed shaft or even particular cutting.
- Completing and processing of data in layers containing graphical symbols of particular types (lines, circles, ...) causes that the software for technological process design has to perform operations of recognition of elementary graphical objects basing on analyses of graphical notation of these elements (reconstruction of drawings in the technological aspect).
- Storing information of graphical image instead of storing information in the objectual form of elementary object components and relations between them.
- Storing construction description data in typical formats for older vector graphic systems using elementary drawing components (lines) instead of using objects which will draw themselves as the result of code interpreter operations.
- The last disadvantage can be clarified through a comparison of different description methods: construction drawings and description methods of document structures (XML) and internet pages (HTML). From this comparison we can find out that instead of storing a vector drawing, object features can be recorded and the interpreter recreates the drawing on any operating system with the use of universal software. After changing the object features, this drawing will be recorded as a set of features again. It is worth to notice that the proposed solutions of object feature notation allow for arbitrary advancement of notation integration of construction features and technological process features, and also organizational instructions. It ought to be admitted that remain such cases for which the verbal or symbolic description would not be unequivocal enough. Then data in the graphical form will play an important role. The supplementary information will also provide data from reconstruction processes of shapes and dimensions in the graphical and numerical form.

In the complex design tasks [9], the release of designer engineers from manual usage of slow interfaces, will allow for elimination of an indirect phase

(composing of drawings from graphical symbols). The phase degrades objectual perception of designed object elements to the layered and fault level for further project usage. The application of intelligent interaction systems aims at the increase of the designers' efficiency and convenience, and rapidity of creation of new constructions.

The current research has focused on the addition of a supplement to CAD systems [9, 10], which consists of simple mechanisms of providing information in the vocal form (in a form of a simple interface for recognition of selected elementary shapes). In that work the objective was to simply support the tasks in traditional systems (simple interface for selective control of a CAD system).

3. Description of the System

The general concept [1] of interactive automated design of machine elements and assemblies is presented in the abbreviated form Fig. 4. The block diagram presents a general procedure of the intelligent designing subsequent steps. The numbers in the cycle represent the successive phases of the information processing.

The system performs biometric identification of the design engineer whose spoken messages in a natural language are converted to text and numeric values. The recognized text is processed by the meaning analysis subsystem performing recognition of words and messages. The results from that natural language interface are recognized meaningful messages with essential information, which are sent to the subsystem of construction analyses. The analyzed constructions are processed by the subsystem of construction encoding. The novel language for construction notation is used for encoding of the constructions. The next phase of the processing is in the subsystem of construction assessment.

The intelligent designing system allows for optimal control of CAD systems using natural language communication by speech, handwriting and freehand drawing. The messages are processed by the intelligent interface using artificial intelligence methods. The processing [1, 11, 12] involves the meaning analysis of words (Fig. 5), messages (Fig. 6) and sentences in a natural language. Therefore the system is capable of designing optimal constructions of machine elements and assemblies. It is also capable of determination of optimal design process parameters and progress decisions with the aim of supporting the design engineer.

The novelty of the system also consists of inclusion of several layers for symbolic notation of construction features and archiving and processing of construction description data using a new object oriented language for construction.

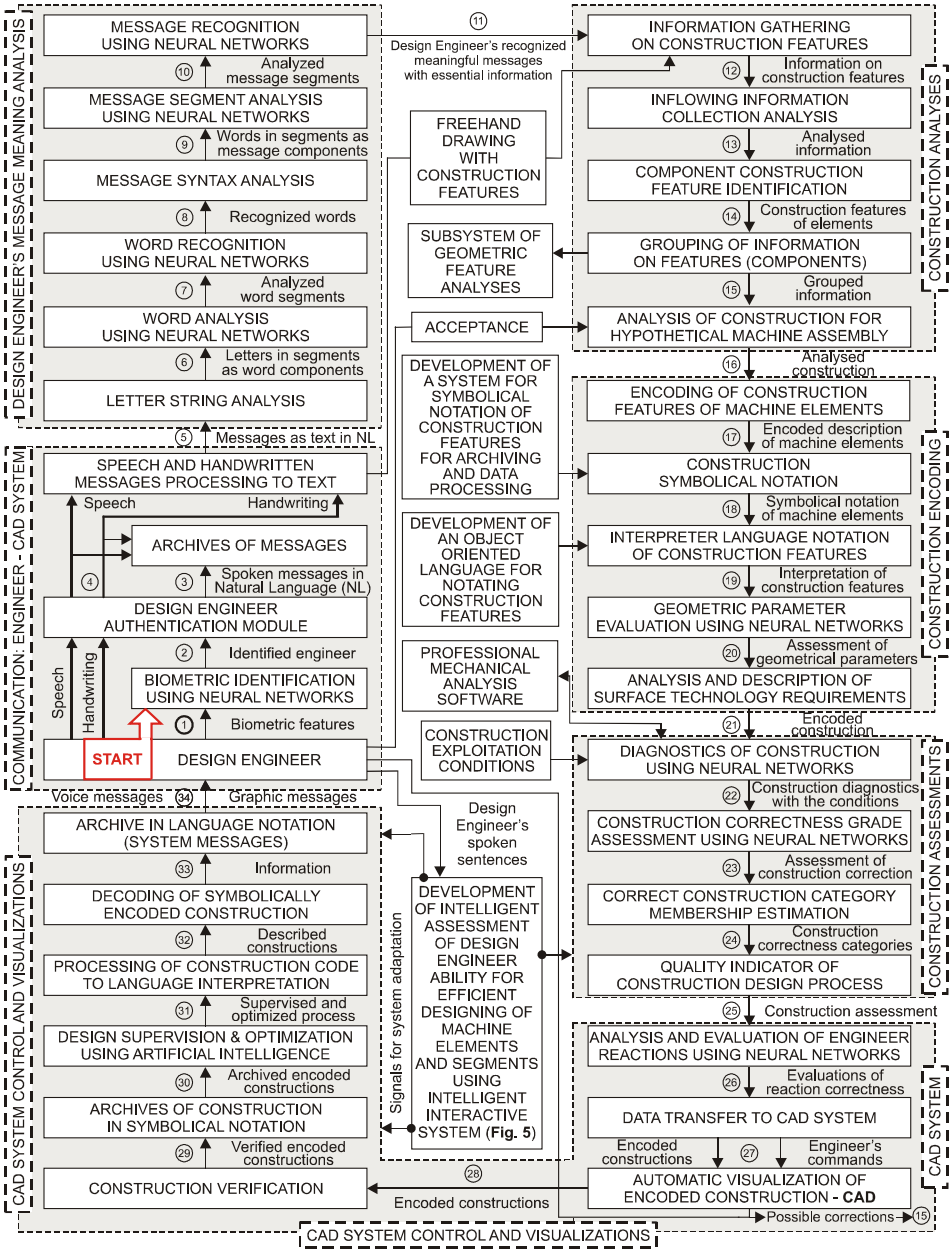

Fig. 4. The general concept of interactive automated design of machine elements and assemblies [1]

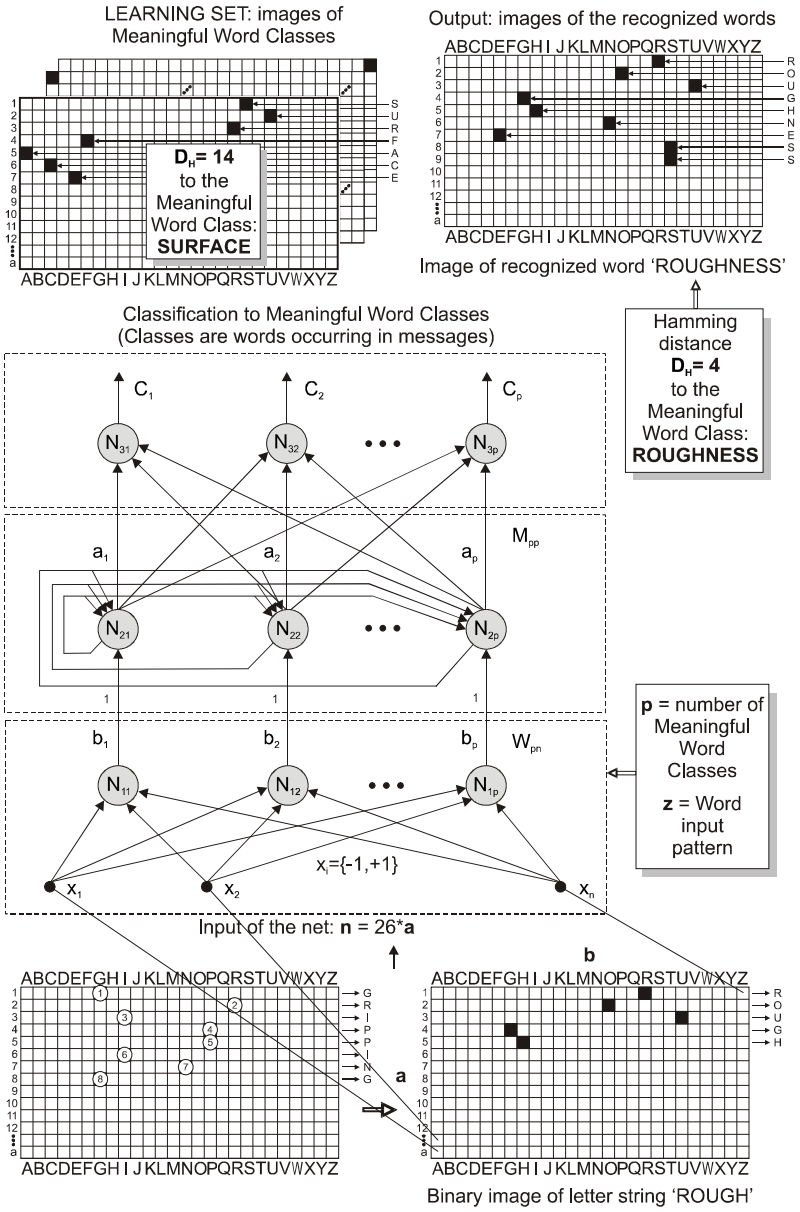

Fig. 5. General concept of word recognition using neural networks [11]

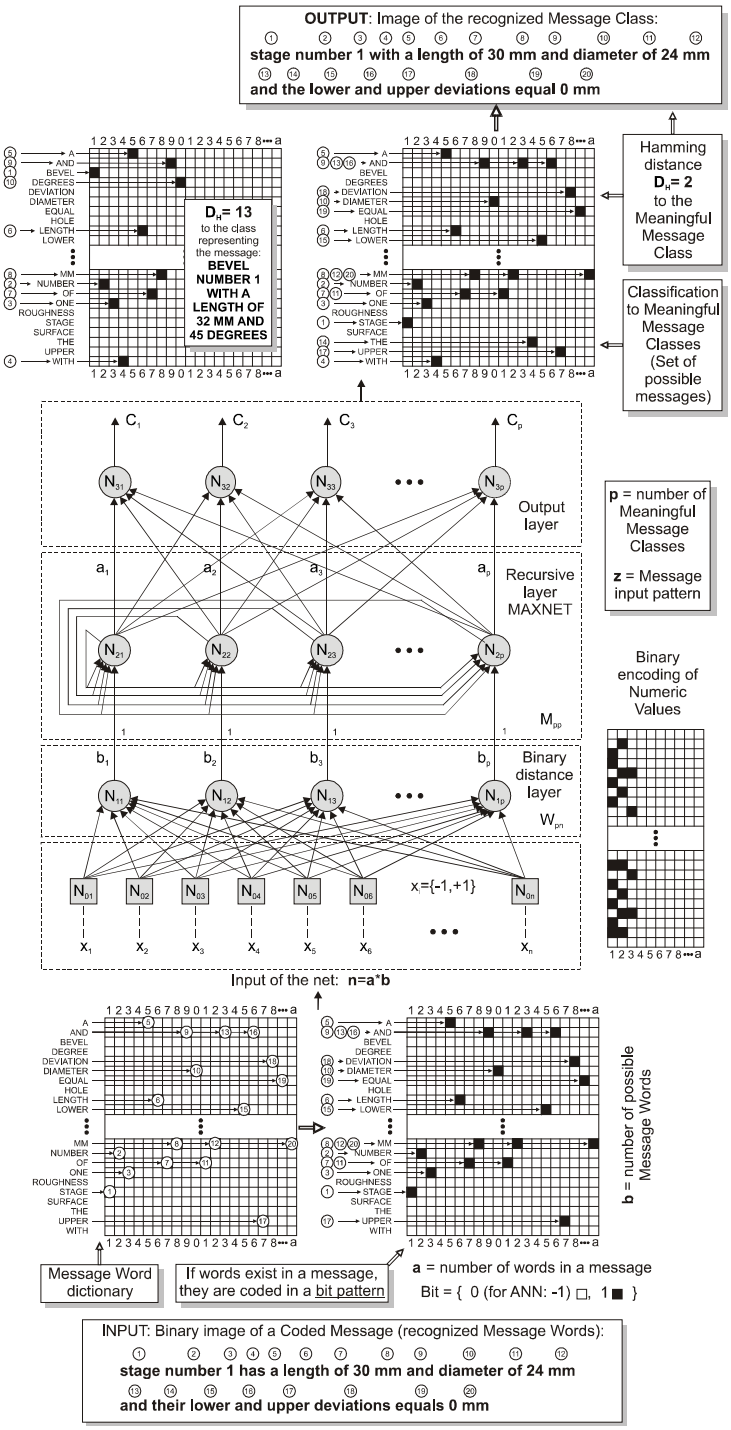

Fig. 6. General concept of message recognition using neural networks

4. Conclusions and Perspectives

The main effect of the realization of the research was the following:

- Higher level of designing through the complete advantage of designers' creativity, relieving designers from doing tasks involving creation of graphical image of elements.
- Increase of rapidity of design process, particularly of complex elements.
- Convenience of modifications and evaluation of many solution variants.
- Automation of the most laborious tasks in the design of machine elements.
- Development of an object oriented language for construction notation and methods for symbolic notation.
- Improvement of operations of data processing and archiving.
- Development of an artificial intelligence system aiding design processes.

The main results of the research are brand new effective systems for designing machine elements without the use of standard interfaces for inputting data. Directing of designer's creative potential to the conceptual tasks with relieve from performing graphical tasks with use of simple systems for communication with computer applications. The technological effect of the research is appreciable reduction of time for implementation of new and modern products.

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