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DEVELOPMENT OF A FUZZY TRANSDUCER

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ABSTRACT

The conception of the fuzzy transducer, an intelligent measuring device is introduced. It consists of a sensor and the inference engine and gives a measuring signal in a form suitable for human perceptional observation.

Key Words: Fuzzy Transducer, Intelligent Measurements, Fuzzy Sets.

INTRODUCTION

The idea of fuzzy sets or fuzzy subsets of real space (1,2) allows mathematically tractable modelling of the imprecise knowledge on a signal and a solution of the subjective and vague control tasks. During the last decades the fuzzy set theory has been developed and applied in various fields, but still the application of the fuzzy sets as a modelling tool for presentation of poorly defined quantities and signals has not been fully explored, but only mentioned by Finkelstein and Leaning (3) and partly explored by Sydenham (4). Sydenham suggests that the future measurement systems can use not only deterministic measurements, but also heuristic metrology, which will feed parallel a deterministic model and a fuzzy model contained in advanced intelligent, knowledge-based systems.

Our approach is based on a different conception, that is, the application of a fuzzy measuring principle in the intelligent measurement of the ill-defined phenomena, or, generally, in cases of indistinct and doubtful values of measuring signals. The true use of intelligence in measurement instrumentation is the integration of the measurement information processing into the total information system in which the measurement process is embedded (5). An example of the application of such a method in vibration analysis is proposed by Filbert (6). For the same purpose the fuzzy transducer has been conceived and studied, but particularly having in mind two possible advantages:

- simpler design of the measuring equipment,
- application in control and diagnostics equipment.

A brief presentation is made of the advance of the development of the fuzzy transducer.

THE FUZZY MEASURING PRINCIPLE

Let us suppose that approximate and imprecise measuring information is obtained through our measurement. It could be caused either by the nature of a phenomenon and our impossibility to measure it accurately enough, or by the economic reasoning which does not permit the investment in the highly precise measuring equipment. It may be also noted that the measuring quantity serves as a control information or as a diagnostics information in condition based maintenance.

The two basic cases may be investigated:

(a) The factor of uncertainty appears only in the presentation of a measurand for the intended processing, while the processing itself is given in a functional form, and

(b) The factor of uncertainty appears in a presentation of a measurand, but there are also the uncertainty and doubt in processing algorithms or in the measurand -measuring signal relationship.

The originally conceived laboratory apparatus shown in FIGURE 1 has been designed as an experimental support for the study and theoretical interpretation of the considered cases.

The case (b) is a general situation, and it may be used in the explanation of our approach to the idea of the fuzzy transducer as an intelligent measuring device.

The generator of the pseudo-random signal (see FIGURE 1) exites an electromagnetic coil and produces continuous monotonous deflections or vibrations of the metal beam. The strain caused in the beam is measured by means of the strain gauge bridge, and the measuring signal transformed in accustical and/or visiual signals acceptable to the operator (8). The operator's task is to estimate and to express the intensities of these signals by means of linguistic values (for example: positive small, positive very small or negative medium, negative large) and to transmit them into the computer by using mnemotic code which is adequate to the considered linguistic expression. In the computer a corresponding fuzzy set is being associated with these linguistic values by means of the precisely defined fuzzy language. The set presents the mathematical model of the estimated deflections of the metal beam.

Let us suppose that the realtion between the beam deflection and a control signal necessary to maintain the beam in certain steady deflection has been also estimated by means of previously described procedure, and that it is prepared in form of production rules: "if the input is positive very small, then the control signal is positive small to medium". That is a conventional situation of the fuzzy control. The input signal is given in the form of the fuzzy set, X^*, and mathematical model of the set of control rules in the form of relation, R^*. Corresponding manipulating signal may be produced by the interpretation of the fuzzy set of the manipulated signal, y^*, obtained by the composition,

$$y^* = X^* \circ R^*$$

Therefore the operator serves only as an estimator of accustic or visual signal and does not need to know anything about its interpretation or about control. The set of control rules has been shaped during the design period and preliminary experimental research. The operator must be only instructed how to recognize the variation of the accustic or visual signal and give it a lingustic value. His only effort is just to produce the best possible linguistic descriptions of the observed accustic or visual deflections.

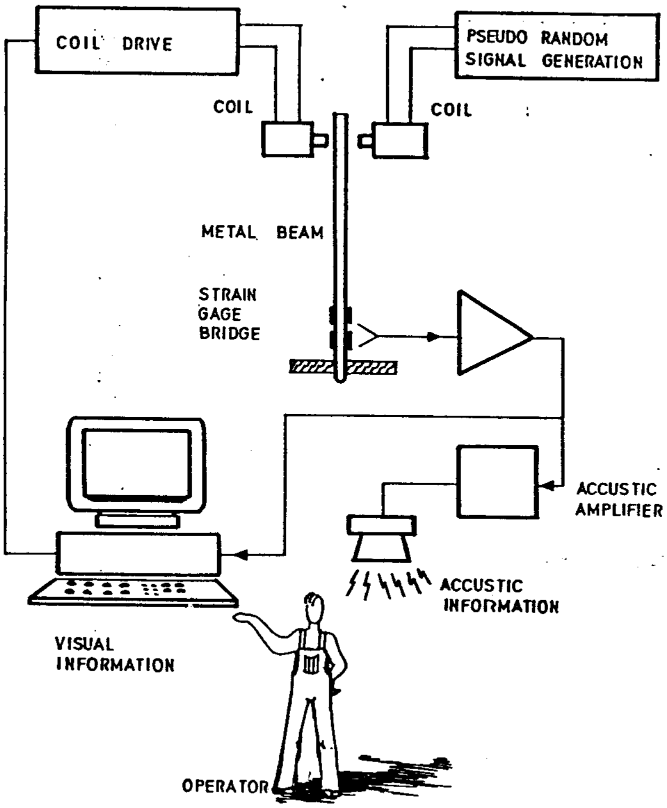

FIGURE 1 - Laboratory apparatus for the investigation and study of the fuzzy transducer principle

Let us consider now that the observed fuzzy signal serves as one of the information on the condition of a machine. Other information may be either in fuzzy form (for example information on another strain) or deterministic (for example information on temperature). Like in previous example, it is possible to define the relation between the available information and the condition of the machine. It may be an expert system or a knowledge base for condition based monitoring presented with the set of production rules in form "if ..., then ...".

A special case is a situation in which the factor of unceratainty appears in the presentation of a measuring signal. Then, the control procedure is not given in form of linguistic rules, but in form of deterministic control rule, u = f(x). The fuzzy signal, X*, should be interpreted and presented by one real value X, and then the adequate control signal may be determined.

One may ask why the operator does not estimate the value x? The use of the hedges and conectives makes the linguistic expression of values (for example x = "very small but not explicitly small") much easier. By application of the presented ideas it is possible to use the properties of natural languages (which are not precise, but have reach possibilities of expression) instead of the expensive and complex deterministic measurements.

4

SUMMARY AND CONCLUSION

The conception and possible principles of the fuzzy transducer are presented. The fuzzy transducer is conceived as an intelligent measuring device, which consist of a selected sensor and the inference engine and which transforms the measurand in the signal suitable for human perception. The originally designed apparatus serves in experimental research and the fuzzy transducer with accustic output signal and visual output signal (on the computer monitor) is studied in detail. Its applications in process control and it technical diagnostics are considered. The first results of the research are promising.

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