

ON THE KNOWLEDGE-BASED EXPERT SYSTEM FOR MARINE INSTRUMENTATION

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ABSTARCT

The combination of intelligence and marine instrumentation has pushed the frontiers of oceanography to great heights. One of the frontiers is the development of knowledge-based expert systems (KbES). Marine instrumentation demands a comprehensive set of requirements, integrating diversified technologies into the intelligent system (that can be programmed, controlled and made easy to operate). Extensive search of knowledge-base is, in general, involved particularly while choosing the appropriate digital IC logic family. Knowledge development process for an expert system is discussed in the paper.

1. INTRODUCTION

In-situ data collection in the ocean is expensive and unpredictable even when the programme is well planned and executed. In spite of the inherent difficulties, little guidance is found in the literature to assist in the planning and organizational stages. Marine instrument design programme can be conceptualised into the following steps:

- identification of the objectives,
- identification of the data to be obtained,
- detailed electronic design (including selection of sensors with proper resolution, accuracy and logistics)
- implementation of the design (incorporating any modifications whenever found necessary).

Artificial Intelligence (AI) originally a branch of computer science has entered in commercial technology enabling computers to perform intelligent actions normally attributed to human beings. One of the most promising areas of applied AI is the 'expert system' (ES) used to solve problems requiring the knowledge and skill of human expertise [1]. The last few years have seen an increasing interest in the development of knowledge based expert systems (KbES) [2].

2. METHODOLOGY

Knowledge representation is basically the link that binds much of AI together. In contrast to conventional database systems, AI systems require knowledge-base with diverse kinds of knowledge. These include knowledge about - objects, time, goals, motivation, actions, etc; in brief, classified as objective (quantitative) and subjective (qualitative). A general knowledge representation is provided by Brachman and Smith [3], while summaries are given by Barr and Piegenbaum [4]. Most of the knowledge-systems incorporate knowledge through rules and data structures.

Marine instrument designer has to make a large search for choosing the appropriate components, particularly digital Integrated Circuits (ICs) logic family from a knowledge-base. The knowledge development process for an expert system leading to a proper decision on the selection of ICs is being discussed.

A long standing need is felt to have a large knowledge-base expert system particularly to provide advice on the circuit design for marine/oceanographic instruments. The rules are a combination of a set of procedures which are user modifiable. The knowledge-base consists

of a large number of criteria, conditions, specifications on the various types of digital logic families. The criteria for decision making is:

- whether sufficient information is available,
- whether conditions for selection of proper components for a particular design are satisfied.

Generally, a marine instrument engineer requires an exhaustive search of component particularly constrained by two factors [5]:

- lack of electrical power from the shore (low power devices);
- harsh marine environment (high relative humidity).

Hence, out of the electronic (digital) logic family of RTL, DTL, TTL, LSTTL, nMOS, pMOS, CMOS, PLEs the choice falls on:

- * LSTTL : Low Power Schottky TTL,
- * nMOS : n-channel MOS,
- * pMOS : p-channel MOS,
- * CMOS : Complementary Symmetry MOS,
- * CMOS PLEs: CMOS Programmable Logic Elements.

The basic characteristics of these devices are described in RL Morris and JR Miller [6], and PLE Handbook [7]. The selection of devices can be made based on the following characteristics:

- fanout (n),
- noise immunity (dc and ac),
- power dissipation per gate (mW),
- ambient temperature ($^{\circ}C$),
- operating RH (%),
- clock rate (MHz),
- propagation delay per gate (nS),
- switching speed,
- input characteristics,
- output characteristics, and
- power supply voltage.

The knowledge bank consists of all the above mentioned categories of information (values). In addition, the above categories can further be sub-divided into a large number of sub-categories. As an example, 'fan-out' < 5 or $5 < f < 10$; etc. These bits of knowledge can be coded and stored as knowledge information bits (knits, in short) in the knowledge-bank, after sub-dividing the main categories into a large number of thinkable categories. These categories and sub-units can thus be arranged in a matrix organisation as:

C_{11}	C_{21}	C_{31}	C_{41}	C_{51}	C_{61}	C_{71}
C_{12}	C_{22}	C_{32}	C_{42}	C_{52}	C_{62}	C_{72}
\vdots						
C_{1n}	C_{2n}	C_{3n}	C_{4n}	C_{5n}	C_{6n}	C_{7n}

Once the design engineer has identified the required specifications: environmental and functional parameters can be expressed in terms of ('knits' out of) C_{11} to C_{7n} . The number of functions thus identified for a particular application, now represents the availability of complex circuits. Comparison can now be made based on the AND-OR rules within the category of ICs [8].

The basic concept underlying this design, is the use of minimum but sufficient amount of knowledge-base (Kb) to design an optimum solution in the form of an expert system (ES). The standard minimization techniques such as Karnaugh-map or Quine-McCluskey methods could be used to arrive at the minimised design in a marine instrument design programme with particular emphasis on oceanographic applications. (Fig.1)

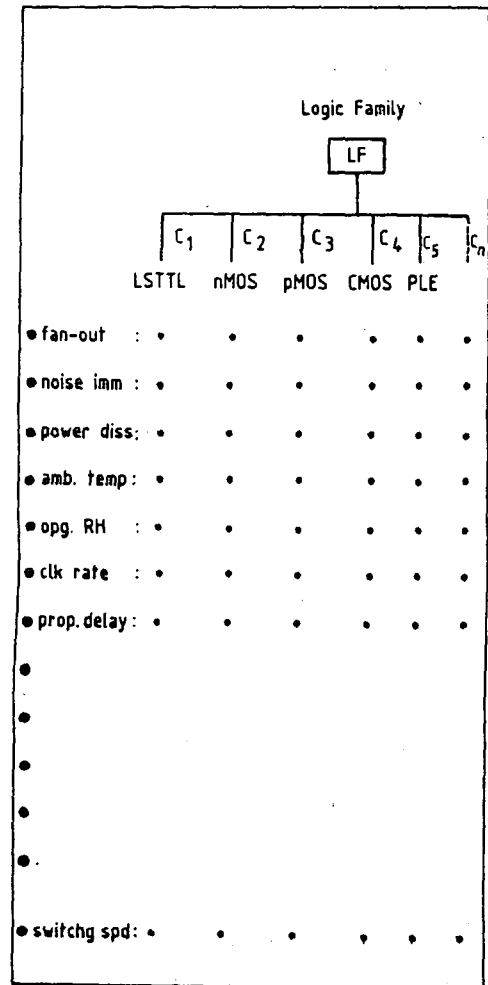


Fig. 1 Logic Families classification

All the knowledge representation characteristics can be correlated during the selection of knowledge representation formats to reduce repetition. The variety of knowledge is stored using a data based on a widely divergent internal storage structure. The decisions for the selection of appropriate components by accessing the knowledge representation formats, and the system control structure is an important stage of the design. Although the sequence and extent of operations execution may change, the manner of monitoring, tracking and extracting the relevant inference decisions does not.

3. CONCLUSIONS

In general, marine instrumentation can be conceptualised into several steps, viz;:

- identification of objectives,
- identification of the data from the knowledge-bank,
- detailed design of the programme including selection of the components and monitoring network,
- data processing, and
- data analysis.

As an example of the application of knowledge engineering in the early stages of the design, the role of knowledge-base in the understanding of the specifications is considered here. When the product is to be designed, the desires of the user must be represented in the form of the specifications according to which the design process is carried out. The designer then addresses the knowledge-base for decision-making to select the appropriate logic family for the specific marine application. Emphasis is given particularly to the role of knowledge-base in expert systems of the future. This being a new field, it is expected to have a wide range of applications particularly in the design of marine instruments for long-term, remote, unattended operations. The continuation of effort is anticipated in the future development in this area.

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