Software for Analysis and Design of Digital Systems in Education: A Comparison between BOOLE-DEUSTO and LogicAid

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1. INTRODUCTION

Software is an important teaching tool in introductory digital electronics courses. Many professional packages suit the requirements of these courses, such as OrCAD, ISE (Xilinx), ElectronicsWorkBench, and MaxPlus II (Altera). However, while these packages are versatile, powerful, and used in the workplaces where students will end up in, they lack ease-of-use and the didactic approach which is needed by both students and teachers in introductory courses. Furthermore, professional packages focus mainly on the final results of a problem, instead of focusing on the methodology used to solve that problem.
The need arises for an education-oriented software package that can allow a student to perform the analysis and design of digital systems in a methodology-driven manner. These packages should not be a substitute for professional packages; they should be a complement which can ease the student's first steps in digital electronics. BOOLE-DEUSTO [1] (developed by the University of Deusto, Bilbao, Spain) and LogicAid [2] (developed by the University of Texas at Austin, USA) are two such software packages. This paper is divided into three parts: a short introduction to BOOLE-DEUSTO, a comparison between BOOLE-DEUSTO and LogicAid, and the conclusions of this comparison.

2. BOOLE-DEUSTO

BOOLE-DEUSTO can carry out analysis and design of bit-level combinational and sequential circuits. The underlying philosophy of BOOLE-DEUSTO is to act as a 'boolean calculator' which can help the student perform digital electronics exercises, the same way a traditional calculator helps high school students perform math exercises. However, since BOOLE-DEUSTO is designed as a learning aid, and focused on methodology and not results, when a student uses it to solve an exercise, he will not only receive a result (which is what traditional calculator do), he will also be able to see the process used to arrive at that result.

Table 1 summarizes BOOLE-DEUSTO's main features and methods. Figure 1 shows screenshots of BOOLE-DEUSTO's most popular features (the Veitch-Karnaugh module and the FSM interactive simulation).

Combinational Circuit	Finite State Machines
Boolean Expression	Moore-Mealy's Diagrams
Truth Table	FSM verification
Veitch-Karnaugh Diagrams	State Minimization
Canonical Forms	Moore -> Mealy Conversion
Minimized Expressions	Tables and Minimized Expressions
NAND/NOR Expressions	J-K and D Circuit Logic
Circuit Logic	Interactive and batch simulations
Code Generation: VHDL, OrCAD-PLD, ABEL, JEDEC, etc.	Code Generation: VHDL, OrCAD-PLD, ABEL, JEDEC, etc.

Program-wide features
Save and load systems to/from disk
Print systems in their various representations
Associate text with a system

Table 1. BOOLE-DEUSTO Features

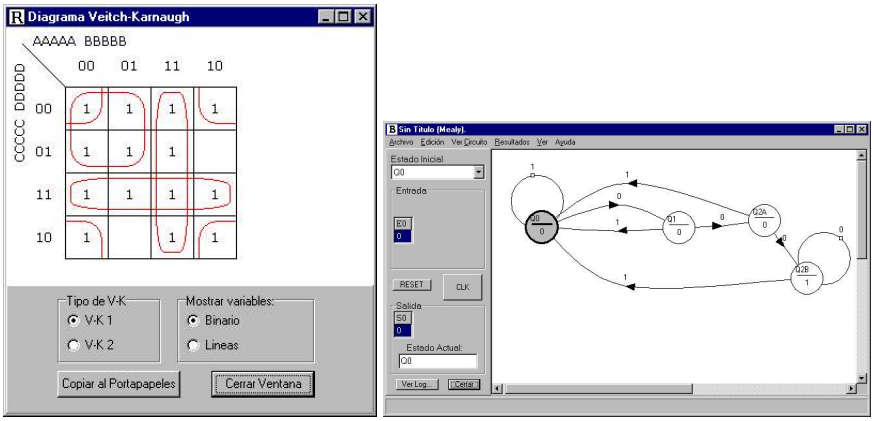

Fig. 1. Veitch-Karnaugh module and interactive FSM simulation

3. COMPARISON BETWEEN BOOLE-DEUSTO AND LOGICAID

LogicAid, developed by the University of Texas at Austin, is another well-known software package which is suited for its use in digital electronics courses. Both BOOLE-DEUSTO and LogicAid are high quality teaching aids, yet they do not provide the same functionality. The goal of this paper is to analyze their differences between them and see how each could benefit from the other's features.

3.1 SUITED FOR DIGITAL ELECTRONICS EDUCATION

Both software packages have been designed from the start to be used mainly in a classroom setting, and therefore are well suited as an aid for digital electronics courses. Both programs feature a user-friendly interface which is easy to work with.

3.2 GENERAL STRATEGY

One of the primary concerns when designing BOOLE-DEUSTO was that the user should be able to use different representation methods (see 3.3) interchangeably with ease, enhancing the notion that several representations (a truth table, a circuit diagram, a Veitch-Karnaugh map) can all represent the same system. In effect, the user can input a system using a boolean expression, and then instantly see how that system would be represented with a VK map, in canonical form, etc. As mentioned previously, this makes BOOLE-DEUSTO act as a 'boolean calculator', where the user can input the description of a system and then experiment with it, the same way a high school student can experiment with all the features of a scientific calculator.
On the other hand, although LogicAid does allow the use of different representation forms, passing from one form to another one is cumbersome (the user has to save the system to a file and reopen it from the other representation form). The user generally has to stick to one representation method at a time, which makes the learning process too guided and not very open to experimentation.

3.3 FORMS OF REPRESENTATION

BOOLE-DEUSTO and LogicAid both allow the user to work with the most common forms of representation used in digital electronics (truth tables, Veitch-Karnaugh maps, canonical forms, etc.) However, BOOLE-DEUSTO has a more complete and versatile set of representation forms. The following are some noteworthy features of BOOLE-DEUSTO which cannot be found in LogicAid:

- Input a digital system in the form of any boolean expression, using any combination of AND, OR, XOR, NOT and parenthesis operators.
- The Veitch-Karnaugh module can also represent any system (LogicAid can only show systems with up to 5 variables).
- Circuit diagrams can be generated from the system description (both combinational and sequential)
- Sequential systems can be simulated graphically (using the FSM diagram) once they have been specified.

3.4 INTERNAL ALGORITHMS

LogicAid features much better internal algorithms than BOOLE-DEUSTO.

While the latter only offers a simple (yet exact) single-output Q-M variant for boolean minimization, LogicAid offers several minimization methods, including the well-known Espresso method, which can perform multiple-output minimization.

3.5 EXPORT FORMATS

Both programs export combinational and sequential systems to well known formats. However, LogicAid currently only exports systems to JEDEC files, while BOOLE-DEUSTO can also generate OrCAD-PLD and VHDL code.

3.6 BIT-LEVEL AND WORD-LEVEL

Neither BOOLE-DEUSTO nor LogicAid work at word-level, since they can only perform bit-level analysis and design. However, LogicAid includes a partner program called SimUaid that allows the user to perform word-level analysis and design by directly editing and simulating logic circuits.

Feature	BOOLE-DEUSTO	LogicAid
General learning strategy	Boolean calculator	Guided learning
Representation methods	Many	Few
Internal algorithms	Normal	Excellent
Export formats	JEDEC, PLD, VHDL	JEDEC
Level of operation	Bit-level	Bit-level and word-level (SimUaid)

Table 2. Summary of comparison between BOOLE-DEUSTO and LogicAid.

4. CONCLUSIONS AND FUTURE LINES OF WORK

BOOLE-DEUSTO and LogicAid are the two leading software packages for digital electronics education. They are both very high quality products, each with a set of distinct features that makes them appealing to students and teachers.

BOOLE-DEUSTO is still being actively developed in the University of Deusto, and the two main lines of work in the future involve learning from what LogicAid offers that BOOLE does not: improving the internal algorithms and supplying a word-level analysis and design tool.

Acknowledgment

BOOLE-DEUSTO is part of the project LOGBOT supported by the Regional Goverment of the Basque Country (Spain): Department of Industry, Commerce and Tourism, SAIOTEK 2002, OD02UD05.

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