Faculty and Researchers | Faculty and Researchers' Publications

1992-05

Profiles of topics and authors of the International Symposium on Multiple-Valued Logic for 1971-1991

Butler, Susan W.; Butler, Jon T.

Profiles of Topics and Authors of the
International Symposium on Multiple-Valued Logic for 1971-1991*

Susan W. Butler
Defense Manpower Data Center
99 Pacific Str., Suite 155
Monterey, CA 93940-2543

Jon T. Butler
Dept. of Electr. and Comp. Eng.
Naval Postgraduate School, Code EC/Bu
Monterey, CA 93943-5004

Abstract

We consider the growth of multiple-valued logic over the 21 year period from 1971 through 1991, as indicated by papers in the International Symposium on Multiple-Valued Logic. Of specific interest are 1) trends in research topics. This includes patterns of growth and decline. We also consider 2) the demographics of the contributing authors. This includes the distribution of authors by country, the percentage of authors who are new, percentage of new authors who return, and the distribution of authors by affiliation (academia, industry, and government). To derive these statistics, we developed a database of papers, authors and topics. This can be used, for example, to do library searches or to assign papers to referees.

1. Introduction

It has been thirteen years since the last analysis of papers in the *Proceedings of the International Symposium on Multiple-Valued Logic* (ISMVL). In 1979, Ginzer and Butler [2] presented an overview of the first eight years of this symposium. They discussed the international composition of the organization and percentage of first-time authors. We are now able to examine the first 21 years of ISMVL. The present wide availability of database programs allows us to collect and present data in ways that were impractical thirteen years ago. With these tools, we investigate the growth and vitality of multiple-valued logic (MVL) and examine whether ISMVL is serving the needs of its members.

2. Profile of Papers in ISMVL

A simple but effective way to measure growth is to count the number papers published per year. This ranges from a low of 18 in 1971 and 1972 to a high of 68 in 1989. A general upward trend in the number of papers is shown in Fig. 1.
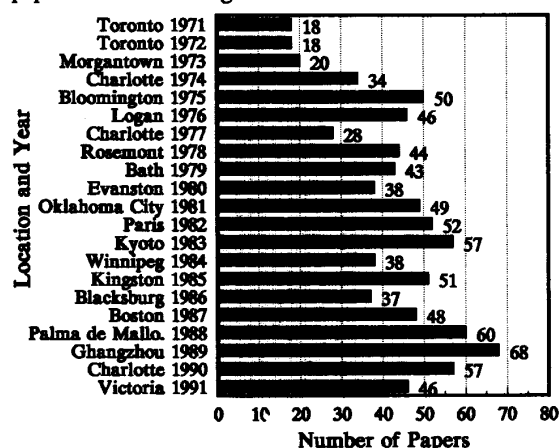

Figure 1. Number of Papers Per Year of ISMVL.

Growth in a discipline is also measured by an increase in the number of areas in which it is applied. Therefore we analyze papers by topic. Papers are first categorized by *major topic*. There are eight major topics, each analogous to a general session category given in the Proceedings. Fig 2. shows numbers of papers in each major topic by year for the past 21 years. A second type of topic is the *minor topic*. The minor topic represents specific areas within a major topic. While the major topic provides a unique classification that tracks broad areas, the minor topic is more specialized and is not unique. Minor topics can span major topics. For example, the minor topic "minimization" occurs under the major topics of fuzzy logic, logic design, and circuits. Every paper is assigned at least one and up to four minor topics. Minor topics are also the best indi-
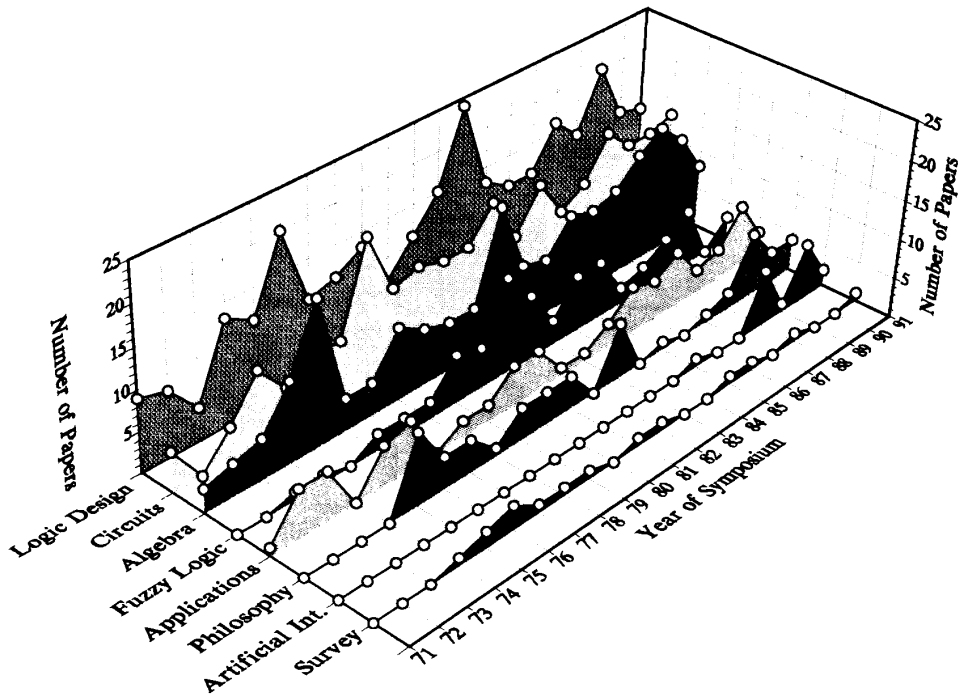
372

Figure 2. Number of Papers by Major Topic by Year.

cators of increasing breadth, as researchers explore new areas, integrate MVL into other disciplines, and carry theoretical results into practical applications. Appendix I lists the 416 minor topics. Some such as "complete-ness" cover many areas and are widely used. Others such as "Oracle" occur in only one paper, but enable researchers to easily locate such papers. Minor topics serve to index the database used to generate the data presented here; the database contains 902 papers, 732 authors, and 1600 author/paper pairs.

Fig. 3 shows the number of papers per year in selected minor topics. We chose these specific minor topics because each one represents a special characteristic, for example, an increase or decrease in research interest. As an illustration, in "approximate reasoning" eight of the nine papers have been published in the last seven years. Similarly, over half the papers on "clones" and "expert systems" have been submitted in the last five years. These represent growing areas on interest. Bio-logical computing has entered the list of minor topics in the last four years and illustrates a new area.

Our results also show topics that experienced a loss of interest. For example, "hazards" and "microprogram-ming" have seen a decline. For both topics, no paper has been published in the last five years, and there has been diminishing interest in the years just prior to that.

Some topics, such as fuzzy (logic), illustrate another characteristic. Certain topics exist as both major and minor topics. That is, a topic may be the subject of a paper that falls primarily into another major category. For example, an application or circuits paper, may util-ize fuzzy logic although not making a direct contribu-tion to it. Another measure of health is the diversification of MVL theory in practical applications. We measure this in two ways, the number of applica-tions papers and the number of different applications topics that MVL papers address. We note from Fig. 2, that there are a substantial number of applications papers. A total of 68 applications papers have been published. These papers cover approximately 50 dis-tinct topics, including, for example, document retrieval and security.
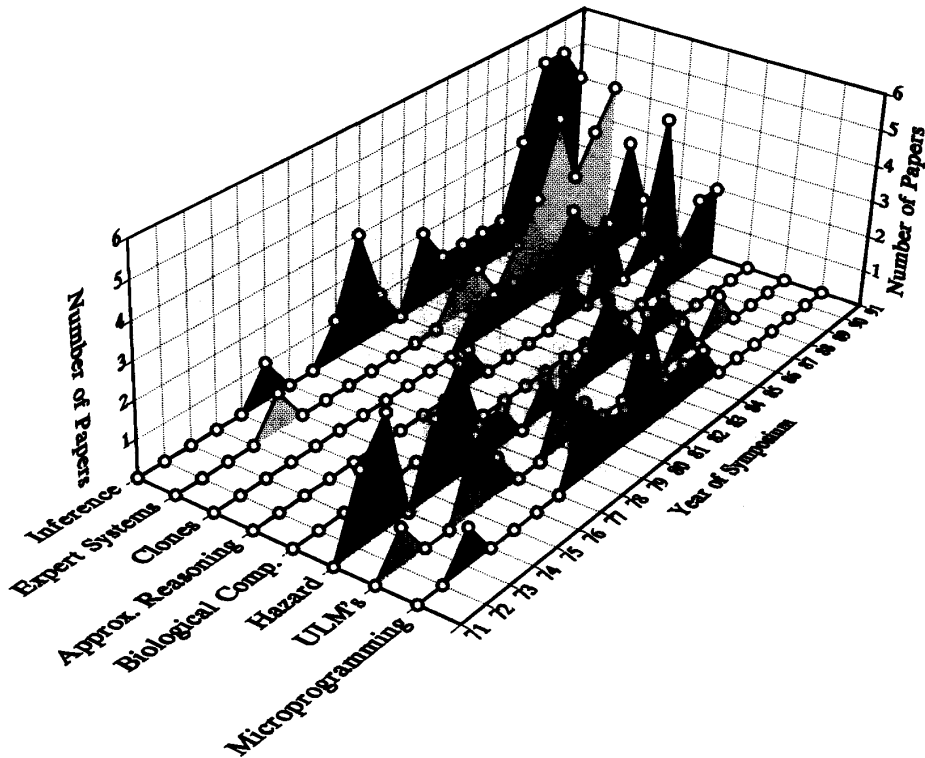
Figure 3. Number of Papers Per Year in Selected Minor Topics.

3. Profile of ISMVL Authors

We next consider the contributors. Fig. 4 shows the number of authors per year. We note that there has been an upward trend over the past 21 years.

Of special interest is the number of researchers who contribute a paper to the ISMVL for the first time. The ability to attract new researchers is an important measure of the vitality of any discipline. Fig. 4 shows the number and percentage of all authors who were new contributors for each year. For the first symposium, 100% of the authors are new. The percentage of new authors in the second through fifth ISMVL's was between 64% and 71%. For succeeding symposia, this percentage decreased slightly, but has remained generally high. The lowest percentage was in 1977 at 37% and the high was 59% in 1988, with an overall average of about 50%. Related to the new author issue is the ability of the symposium to retain the interest of these first time authors. We, therefore, examined the number of such authors who contributed a paper in some subsequent year. Fig. 4 also shows this data. The largest number of returnees occurred from 1983. Of the 54

new authors, 25 returned in later years. The next largest number, 19, occurred from 1971. As expected, the percentage of new authors who return drops for more recent symposia, since there are fewer opportunities for attendance. The overall average, 32%, shows a healthy continuing interest in MVL.

Fig. 5 shows a histogram of productivity of ISMVL authors. Counting authors with many papers gives a sense of how many have a strong commitment to MVL. In the past 21 years, 23 authors have contributed more than 10 papers each, and one author has contributed 32. As expected, many authors, 481, have contributed just one paper.

Fig. 6 shows an interesting, related trend. Plotted here is the number of authors divided by the number of papers per year. This is not the average number of authors per paper because of authors who have more than one paper that year, but it is close. There is a general upward trend. As multiple-valued logic has matured, there are fewer single authors and more group activity. The passage of time has allowed the formation of research partnerships, assimilating new authors into
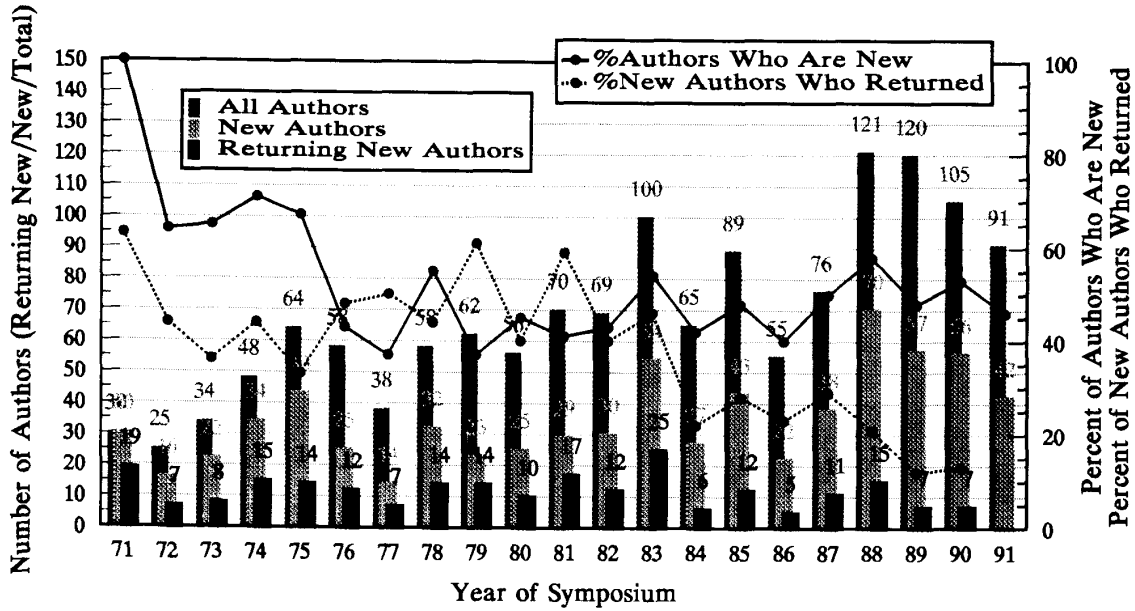
374

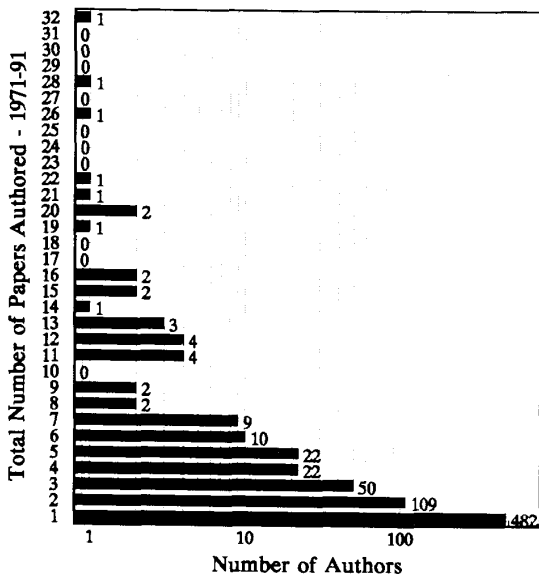Figure 4. Number of Authors and Number and Percentage of New Authors.

Figure 5. Histogram of Paper Productivity.

Figure 6. Number of Authors/Number of Papers.

the research community. We believe this is another indicator of growth and evolving author participation.

Fig. 7 shows the distribution of papers by number of authors for the past 21 years. The vertical axis shows how many authors collaborated on a paper, while the horizontal axis shows how many papers there are with
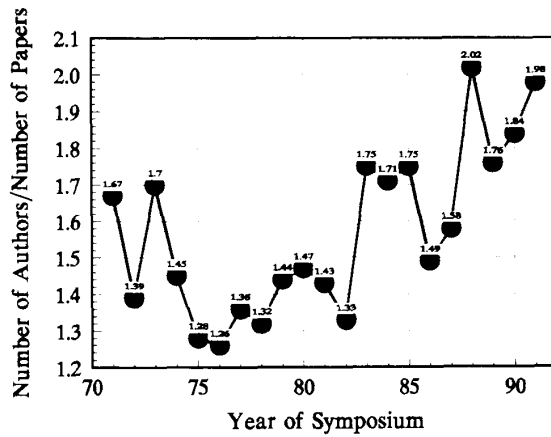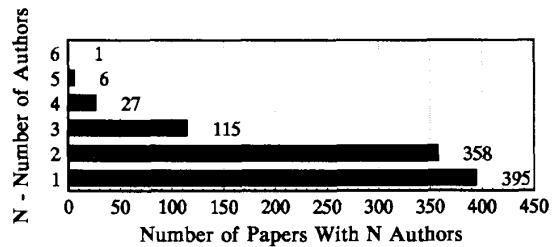

Figure 7. Histogram of Author Multiplicity.

Year / Country	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	Total
Algeria														1								1
Argentina										1										3		4
Australia																		1			1	2
Austria											1	2					2					5
Belgium					2	2	2	3	3			1										13
Brazil												2								3		5
Canada	5	3	6	10	12	12	8	4	5	4	6	6	8	10	11	8	6	14	13	15	17	183
Chile	1	1	2	3	1												1					9
China								1		1	3	3	10	7	17	7	7	15	47	9	2	129
Denmark												1										1
Ecuador										1	1	1	1									4
England				1	4	4		1	12	2	5		2	3	1	2		2	1			40
Finland		3	2	1																		6
France	1		2	2	2	3	4	3	3	4		2		3	4		4	1		3		41
Germany					1	1	3	2	2	1	2	3		2	2	1	4	2	5	4	4	39
Hungary												2	3	3					1	1		10
India				2								1	1									4
Iran																					1	1
Iraq								2				2			2							6
Israel				2	3								1		1							7
Italy												2	3									5
Japan	3	2	3		3	8	7	7	9	8	11	8	39	13	18	10	17	22	23	18	30	259
Korea																				1		1
Mexico																	1					1
Netherlands							1			1	3	2	3		3	2	2	2		2		21
Nigeria										1	1											2
Poland			1	1	6	1	1					2	3	2		2	1			2	2	24
Portugal																				2		2
Saudi Arabia										1	2											3
Singapore																				4		4
South Africa											1											1
Spain					2	2	4	2	2	7	5	1		3	2			26	6	2	4	68
Switzerland				1																		1
Taiwan												1		1								2
USA	20	16	17	25	29	25	10	31	26	29	26	21	24	19	27	20	31	35	18	36	29	514
USSR					1							3							1			5
Yugoslavia															1		1	2	2		1	7
Unknown		1										1							2			4
Total	30	25	34	48	64	58	38	58	62	56	70	69	100	65	89	55	76	121	120	105	91	1434
Year	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	Total

Figure 8. Number of Authors by Year by Country.

that many authors. Single-author papers are the most common, with two-author papers a close second.

4. Profile of the Symposium

From the first symposium in 1971, internationalism has been a hallmark of ISMVL participation. In 1971, authors from five countries (Canada, Chile, France, Japan, and the U.S.) on four continents participated. Fig. 8 illustrates the continuing geographic spread of interest, as a distribution by author's nationality. Some interest-

ing observations can be made. In 1971, 67% (20) of authors were from the U.S., with Canada as the second most prolific contributor. In 1991, authors came from 10 countries world-wide. Japan has taken the lead with 33% (30) of the authors, while the U.S. is a close second with 32% (29). Fig. 8 shows the number of authors contributing according to country over the 21 year history of the ISMVL.

A related factor is symposium location. We consider how the location of a conference affects the retention
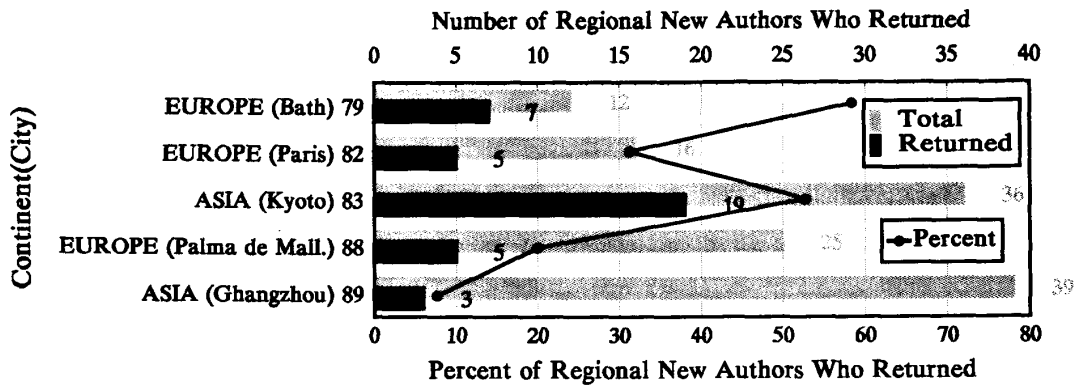
Figure 9. New Author Continuation Data for ISMVL Outside North America.

rate of new authors. Five symposia have been held outside North America - Japan (1983), People's Republic of China (1989), France (1982), Spain (1988), and England (1979). For analytical purposes, we consider the continent of both symposium and authors. At the symposium held in Japan, there were 54 new authors, of which 36 were from Asia. Of these new Asian authors, 19 or 53% have contributed a paper to at least one subsequent symposium. For the conference held in France, there were 30 new authors, 16 of whom were

from Europe. Of these, 5 later returned, a retention percentage of 32%. Fig. 9 shows results for all symposia held outside of North America. Although the results are not as clear for the '88 and '89 ISMVL, because of the lack of time an author has had to return, we believe this data shows there is a benefit to the wider geographical distribution of ISMVL.

As another measure of vitality, we consider whether ISMVL attracts researchers from industry and govern-
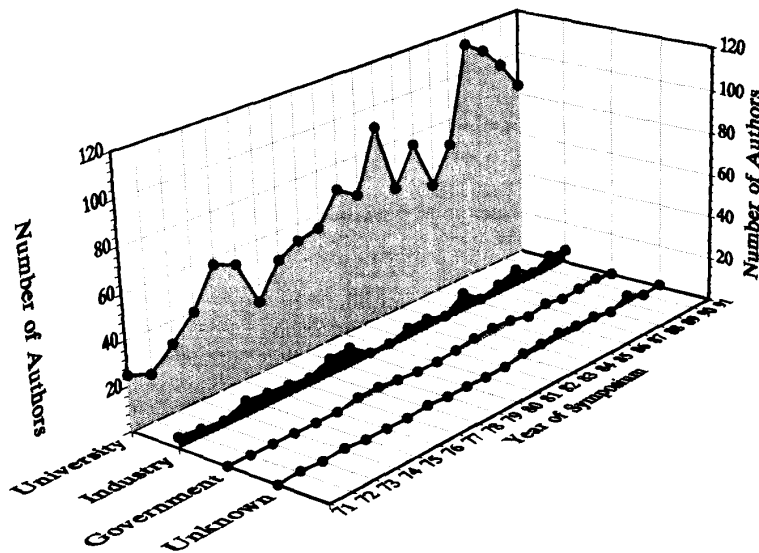
Figure 10. Distribution of Authors by Affiliation.

377

ment, the primary users of technology, and from academia, the primary source of theoretical advances. Fig. 10 shows the distribution of authors by affiliation. Here, the result is less encouraging. Participation by government and industry averages slightly less than 10% of university participation. This identifies one area where efforts can be made to attract researchers.

5. Concluding Remarks

Our analysis shows both topics for which interest is decreasing, as in "hazards", and those for which it is increasing, as in "expert systems" and "clones". Any growing and evolving discipline will demonstrate both these attributes, as areas cease to be fruitful and new areas of exploration arise.

Over the 21 year history of the symposium, approximately 50% of each year's authors are first time contributors. This was a surprising result of the study of the first eight years; it is still surprising. We also considered the retention rate, an average 32%, as significant and positive.

We investigated to what extent the location of the symposia affects attendance. We expected that a conference in a location tends to attract authors from that location, but questioned whether this would stimulate ongoing interest in ISMVL. Our results show, in varying degrees, an increase in follow-on attendance by these authors. Our results also show the need to attract researchers in industry and government.

The overall conclusion of this study is that multiple-valued logic and the ISMVL which serves as its forum, remain healthy. There continues to be a balance between new authors and long-time contributors. There is progress toward practical applications, and there is a harvesting of the benefits of world-wide locations.

Acquiring the Database

The database is available upon request. It is formatted in DataPerfect, a companion database to WordPerfect. To obtain a copy, send a blank high density 3.5" to either author with a self-addressed flopper mailer envelope. No warranty is made on this database.

Acknowledgments

References

[1] J. T. Butler, Multiple-valued logic in VLSI, *Computer Society Press*, Los Alamitos, CA, 1991.

[2] J. A. Ginzer and J. T. Butler, "Multiple-valued logic: 1974 - 1978 -- Survey and analysis," *Proc. of the 9th International Symposium on Multiple-Valued Logic*, May 1979, pp. 1 - 13.

[3] S. L. Hurst, "A survey: Developments in optoelectronics and its applicability to multiple-valued logic," *Proc. of the 16th International Symposium on Multiple-Valued Logic*, May 1986, pp. 179 - 188.

[4] S. L. Hurst, "Two Decades of Multiple-valued Logic - An Invited Tutorial," *Proc. of the 18th International Symposium on Multiple-Valued Logic*, May 1988, pp. 164 - 175.

[5] S. L. Hurst, "Multiple-valued logic: Its status and its future," *IEEE Trans. on Computers*, December 1984, pp. 1160 - 1179.

[6] C. Moraga, "A decade of spectral techniques," *Proc. of the 21st International Symposium on Multiple-Valued Logic*, May 1991, pp. 182 - 188.

[7] D. C. Rine, *Computer Science and Multiple-Valued Logic*, North-Holland, Amsterdam, The Netherlands, 1984.

[8] D. C. Rine, "An historical survey of logic function design for digital computing systems: 1952-76," *Proc. of the 7th International Symposium on Multiple-Valued Logic*, May 1977, pp. 143 - 154.

[9] K. C. Smith, "The prospects of multivalued logic: A technology and applications view," *IEEE Trans. on Computers*, Sept. 1981, pp. 619 - 634.

[10] K. C. Smith, "Multiple-valued logic: A tutorial and appreciation," *Computer*, April 1988, pp. 17 - 27.

APPENDIX I: LIST OF MINOR TOPICS