بسم الله الرحمن الرحيم

**IN THE NAME OF ALLAH,
MOST MERCIFUL, MOST GRACIOUS**

Proceedings of the Seventh Saudi Engineering Conference

Riyadh 2-5, December 2007

Volume IV

Research and development to serve the industry and upgrade its services

Chemical Engineering

Electrical Engineering

PREFACE

The Seventh Saudi Engineering Conference comes to complement the series of Saudi engineering conferences which started in 1402H and have been hosted successively by different colleges of engineering of the Saudi universities. The College of Engineering at King Saud University is honored to host the conference for the second time.

These conferences have greatly contributed to the resettlement of technology, the dissemination and exchange of experiences between engineering professionals, and have helped to promote the scientific research besides advancing innovation and excellence.

At a time of the advanced technology and the availability of information in various ways, nations have become closer and the world is turning into a small village, the economy has become the prime engine of the world. It is necessary for all nations to work hard to cope with this technical progress and benefit from it, and moreover create appropriate conditions to deal with this tremendous development and competition as much as possible. It is incumbent upon all professionals in general and engineers in particular to work hard to provide the proper environment in such circumstances.

As a consequence, The Seventh Saudi Engineering Conference discusses an important and vital theme for researchers, engineers and industrialists. The theme is to provide an Engineering Environment to merge in a Competitive Global Economy in an open and boundary-less economy and profession. This conference is trying to answer this question through well-formulated seven topics.

Conference topics discuss multiple issues related to engineering profession and engineering firm, engineering environment through education and labor market requirements, engineering rehabilitation, preservation of the environment, rationalization of resource consumption, Saudi construction code, development of the engineering sector to diversify sources of national income, and research and development to service the industry and upgrade its services.

The conference proceedings contain 168 refereed scientific research papers which are distributed into a number of volumes, and each volume contains one or more topic. A separate volume for paper abstract is also published in addition to electronic proceedings that includes all papers accepted in the conference. These proceedings will be a scientific reference for engineers in the Kingdom and the worldwide.

Finally, thanks to Almighty God for his help in completing of this work and deep thanks for all members of the Conference Committees for their efforts, and special thanks to members of the Scientific Committee for their efforts to have this documentation of the huge scientific research, which is an important reference for researchers and engineers. Thanks also for authors and experts who have contributed their ideas, their research to the success of the conference.

Thanks

Chair of organizing committee

Prof. Abdulaziz A. Alhamid

INTRODUCTION

Under the high patronage of his Royal Highness the Prince Sultan Ibn Abdulaziz the crown prince and minister of defense, aviation and inspector general, the College of engineering at the King Saud university hosted the Seventh Saudi Engineering Conference during the period 22 to 25 Dhu Alqeeda 1428 corresponding to 2-5 December 2007. The theme issue of the conference is “Towards An Engineering Environment Competitive to the Economics of Globalization”.

The response to contribute in the conference has been most encouraging. A large number of abstracts were received. After a thorough peer-review process for evaluating the submitted papers, the scientific committee has selected a total of 168 papers, presented by 300 researchers. The conference has drawn participants from the different kingdom universities, colleges, institutes and technical education establishments as well as governmental and national companies. The conference has also attracted international participation from universities and institutes of United Arab Emirates, Egypt, Sudan, Algeria, Tunisia, Malaysia, India, Great Britain, Germany, France, Deutschland, Canada, Japan and United States of America.

One of the main objectives of the conference was to contribute to the review and development of important aspects of the engineering sector both public and private. The topics of the conference were chosen to tackle the challenges that engineering education and its outputs are facing. In addition, the themes also emphasized on the contribution of the engineers to the development of the country. The conference themes were as follows:

- Engineering qualification and its role in the strategy of Saudization
- Engineering specialties as viewed from the educational establishments and the job market requirements
- Engineering sector contribution to resources conservation
- Engineering and environmental protection

- The Saudi building code
- Development of the engineering sector for diversification of income resources
- Research and development in the service of industry and for the improvement of services

In addition to the specialized scientific papers that covered the above mentioned themes the conference also hosted a number of plenary lectures and discussion forums that attracted the participation of key policy makers as well as academics and economic parties.

The selected abstracts and papers have been documented in the proceedings which comprise of six volumes in accordance with the conference themes. The papers are also documented in CDs.

Before concluding I would like to express my gratitude to all members of the Scientific Committee for their efforts and active participation to the success of the conference. Thanks are also due to the referees who have been of great help in selecting high quality papers for the conference. The support provided by the secretarial and technical staff of the college of engineering is also thankfully acknowledged.

Finally on my own behalf and behalf of the Scientific Committee I would like to record our appreciation and sincere thanks to His Excellency the rector of the King Saud University and the Dean of College of engineering, the chairman of the organizing committee for their continued support and valuable guidance, We are all hopeful that this scientific conference will be of a support for recruiting engineering specialties on a larger scale and contribute to the growth and prosperity of our country. May Allah Almighty accept our sincere efforts.

Chairman of the Scientific Committee

Prof. Khalid Ibrahem Alhumaizi

Contents

SOME ENGINEERING APPLICATIONS OF THE MODERN SYLLOGISTIC METHOD

Ali Muhammad Rushdi[1] and Omar Mohammed Ba-Rukab[2]

1: Department of Electrical and Computer Engineering, King Abdulaziz University, PO Box 80204, Jeddah 21589, Saudi Arabia, arushdi@kau.edu.sa
2: College of Telecommunications and Electronics, PO Box 2816, Jeddah, 21461, Saudi Arabia, obarukab@yahoo.com

ABSTRACT

We describe the steps and the main features of the modern syllogistic method, which is a very powerful technique of deductive inference. This method ferrets out from a set of premises all that can be concluded from it, with the resulting conclusions cast in the simplest compact form. We demonstrate the applicability of the method in a variety of engineering problems via three examples that illustrate its mathematical details and exhibit the nature of conclusions it can come up with. The method is shown to help a problem solver reach the heart of the real problem by detecting inconsistency within a set of given premises or hypotheses. We also demonstrate how the method can be useful for selective deduction and that it constitutes a substantial aid to informed decision making.

KEY WORDS

Deductive inference, Modern syllogistic method, Detecting inconsistencies, Real and perceived problems, Selective deduction, Informed decision making.

I. INTRODUCTION

One of the important traits of a successful engineer is logical thinking[1]. This trait can usually be acquired and mastered through appropriate training in deductive and inductive logic [2, 3]. Such training does not necessarily guarantee that a person can reason well or correctly, but a person knowledgeable about logic techniques is more likely to reason correctly than one who is unaware of them. In the past, smart individuals realized that they could think logically without resort to the deductive logic techniques that were available to them, while dummy individuals failed to derive any benefit from these techniques, which were complex and cumbersome indeed. Traditional logicians applied deductive logic to contextual reasoning, and were deeply concerned with verbal fallacies. In its modern formal outlook, logic is a science of correct forms in which the study of such fallacies is irrelevant, and it has two distinctive branches of deduction and induction that are both essential as they play complementary rather than competitive roles in inference.

In this paper, we describe the steps, features and some engineering applications of a very powerful technique for deductive inference, which we call "the modern syllogistic method". The first popular description of this method is given by Brown [4]. Later presentations of the method are given Gregg [5] and Rushdi & Al-Shehri [6]. The great advantage of the method is that it ferrets out from a given set of premises all that can be concluded from this set, and it casts these conclusions in the simplest or most compact form.

The remainder of this paper is organized as follows. Section II outlines the steps of the modern syllogistic method, while section III lists its main features. Section IV illustrates some engineering applications of the method in terms of three examples. Example 1 presents typical deductions by the method in the context of a problem of automatic control. Example 2 demonstrates how the method can test hypotheses or detect inconsistencies within a set of premises. This feature is very useful for the engineer in his role as a problem solver, because he can avoid falling into the trap of solving a perceived problem, which is a problem thought to be correctly defined while, in fact, it is not. Example 3 presents a case of selective deduction and informed decision making. Section V concludes the paper.

II. STEPS OF THE MODERN SYLLOGISTIC METHOD

The modern syllogistic method has the following steps:

1. Each of the premises is converted into the form of a formula equated to 0 (which we call an equational form), and then the resulting equational forms are combined together into a single equation of the form $f = 0$. If we have n logical equivalence relations of the form

$$T_i \equiv Q_i \ , \qquad 1 \le i \le n \ , \tag{1}$$

they are set in the equational form

$$T_i \overline{Q}_i \vee \overline{T}_i Q_i = 0 \ , \qquad 1 \le i \le n. \tag{2}$$

We may also have ($m - n$) logical implication (logical inclusion) relations of the form

$$T_i \rightarrow Q_i \ , \qquad (n+1) \le \mathrm{i} \le m \ . \tag{3}$$

These relations symbolize the statements "$If\ T_i\ then\ Q_i$" or equivalently "$T_i\ if\ only\ Q_i$". Conditions (3) can be set into the equational form

$$T_i\,\overline{Q}_i = 0, \qquad (n+1) \le i \le m. \tag{4}$$

The totality of m premises in (1) and (3) finally reduce to the single equation $f = 0$, where f is given by [7],

$$f = \bigvee_{i=1}^{n} (T_i\,\overline{Q}_i \vee \overline{T}_i\,Q_i) \vee \bigvee_{i=(n+1)}^{m} T_i\,\overline{Q}_i. \tag{5}$$

Equations (١) and (٣) represent the dominant forms that premises can take. Other less important forms are discussed by Klir and Marin [8] and can be added to (5) when necessary.

2. The function f in (5) is rewritten as a complete sum (Blake canonical form), i.e., as a disjunction of all the prime implicants of f. There are many manual and computer algorithms for developing the complete sum of a switching function f [4, 9-11]. Most of these algorithms depend on two logical operations: (a) Consensus generation (or equivalently multiplying a product of sums into a sum of products), and (b) absorption.

3. Suppose the complete sum of f takes the form

$$f = \bigvee_{i=1}^{\ell} P_i = 0, \tag{6}$$

where P_i is the i th prime implicant of f. Equation (6) is equivalent to the set of equations

$$P_i = 0, \qquad 1 \le i \le \ell. \tag{7}$$

Equation (7) states in the simplest equational form all that can be concluded from the original premises. The conclusions in (7) can also be cast into implication form. Suppose P_i is given a conjunction of uncomplemented literals X_{ij} and complemented literals $\overline{Y}_{ij}$, i.e.

$$P_i = \overset{r}{\underset{j=1}{\wedge}} X_{ij} \wedge \overset{s}{\underset{j=1}{\wedge}} \overline{Y}_{ij} , \qquad 1 \leq i \leq \ell , \tag{8}$$

then, (7) can be rewritten as

$$\overset{r}{\underset{j=1}{\wedge}} X_{ij} \rightarrow \overline{(\overset{s}{\underset{j=1}{\wedge}} \overline{Y}_{ij})}, \quad 1 \leq i \leq \ell , \tag{9}$$

or as

$$\overset{r}{\underset{j=1}{\wedge}} X_{ij} \rightarrow \overset{s}{\underset{j=1}{\vee}} Y_{ij} , \quad 1 \leq i \leq \ell . \tag{10}$$

III. IMPORTANT FEATURES OF THE MODERN SYLLOGISTIC METHOD

1. The modern syllogistic method produces all possible consequents (since CS(*f*) is a disjunction of all the prime implicants of *f*, and it casts these consequents in the most compact form (since all the implicants in CS(*f*) are prime ones). If any implicant (whether it is prime or not) of *f* is equated to 0, then the result is a true consequent (albeit not necessarily in the most compact form) [4].

2. To test the truth of any claimed consequent based on a given set of premises, one just needs to cast this consequent in the form of a term equated to 0, and check to see if this term subsumes (at least) one of the prime implicants in CS(*f*) derived for the set of premises.

3. The modern syllogistic method encompasses a complete set of inference rules, and constitutes a complete system of truth-functional logic, in the sense that it permits the construction of a formal proof of validity for any valid truth-functional argument [6].

4. The modern syllogistic method has a built-in capability of detecting the existence of inconsistency within a given set of premises, The method will alert its user to the existence of concealed inconsistencies by producing CS(*f*) =1. Once this happens, the user should refrain from making any conclusion, and should revise his set of premises to change it into a consistent one.

5. The modern syllogistic method can be used in detecting and invalidating certain purported arguments or formal fallacies, such as the converse fallacy (the fallacy of affirming the consequent) or the inverse fallacy (the fallacy of denying the antecedent).

6. The modern syllogistic method is very useful in the case of selective deduction [12], which is deduction with the knowledge of certain information or restrictions, or the lack thereof, about some of the pertinent variables. The method handles selective deduction by

   (a) either selecting the appropriate subset of the set of prime implicants in (6) or by obtaining the appropriate conjunctive eliminant [4] or meet derivative [13] of f in (5), and then casting it in complete-sum form [12], or

   (b) restricting the values of appropriate variables by assigning each of them one of the constant values 0 or 1.

7. As a formal technique of logic, the modern syllogistic method concerns itself only with the form of its premises and consequents and has nothing to do with their subject matter. It is up to the user of the method to use plausible heuristics to formulate the premises and interpret the consequents. The intervening task of going from the formal premises to the formal consequents is tackled in a completely algorithmic fashion by the method. By contrast, the heuristics required of the user are fallible, involve some linguistic and verbal elements, and cannot be replaced by exact recipes or algorithms.

IV.EXAMPLES OF ENGINEERING APPLICATIONS

EXAMPLE 1

The following problem is encountered in the study of automatic control systems [14]. For the transfer function

$$\frac{Y(s)}{U(s)} = K\,\frac{(s + q_1)(s + q_2)}{(s + p_1)(s + p_2)}, \qquad (11)$$

a certain state decomposition is uncontrollable if and only if $K = 0$ or $q_1 = p_2$. This decomposition is unobservable if and only if $q_1 = p_1$ or $q_2 = p_1$ or

$q_2 = p_2$. The transfer function has definitely some zero-pole cancellations. What can be concluded from these premises?

Use the following switching variables to symbolize the various propositions

C_{ij} = Zero q_i cancels pole $p_j (q_i = p_j)$, $1 \leq i, j \leq 2$,

S = Decomposition is controllable,

V = Decomposition is observable,

G = The gain K is zero.

The premises can be stated as

Clausal Form Equational form

$$\overline{S} \equiv (G \vee C_{12})$$
$$S\,G \vee S\,C_{12} \vee \overline{S}\,\overline{G}\,\overline{C}_{12} = 0$$

$$\overline{V} \equiv (C_{11} \vee C_{21} \vee C_{22})$$
$$V\,C_{11} \vee V\,C_{21} \vee V\,C_{22} \vee \overline{V}\,\overline{C}_{11}\,\overline{C}_{21}\,\overline{C}_{22} = 0$$

$$C_{11} \vee C_{12} \vee C_{21} \vee C_{22}$$
$$\overline{C}_{11}\,\overline{C}_{12}\,\overline{C}_{21}\,\overline{C}_{22} = 0$$

Then the given data are equivalent to the propositional equation $f = 0$, where f is given by

$$f = S\,G \vee S\,C_{12} \vee \overline{S}\,\overline{G}\,\overline{C}_{12} \vee V\,C_{11} \vee V\,C_{21} \vee V\,C_{22} \vee \overline{V}\,\overline{C}_{11}\,\overline{C}_{21}\,\overline{C}_{22} \vee \overline{C}_{11}\,\overline{C}_{12}\,\overline{C}_{21}\,\overline{C}_{22} = 0 . \qquad (12)$$

The complete sum of f is

$$CS(f) = S\,G \vee S\,C_{12} \vee \overline{S}\,\overline{G}\,\overline{C}_{12} \vee V\,C_{11} \vee V\,C_{21} \vee V\,C_{22} \vee \overline{V}\,\overline{C}_{11}\,\overline{C}_{21}\,\overline{C}_{22} \vee \overline{C}_{11}\,\overline{C}_{12}\,\overline{C}_{21}\,\overline{C}_{22} \vee S\,\overline{C}_{11}\,\overline{C}_{21}\,\overline{C}_{22} \vee V\,\overline{C}_{12} \vee S\,V = 0. \qquad (13)$$

In addition to the old premises, we have three new conclusions

(1) $S\,\overline{C}_{11}\,\overline{C}_{21}\,\overline{C}_{22} = 0$ or $\overline{S} \vee C_{11} \vee C_{21} \vee C_{22} = 1$ {Either the decomposition is uncontrollable , q_1 cancels p_1 , q_2 cancels p_1, or q_2 cancels p_2 (or any combination thereof)}.

(2) $V\,\overline{C}_{12} = 0$ or $\overline{V} \vee C_{12} = 1$ {Either the decomposition is unobservable or q_1 cancels p_2 (or both)}.

(3) $S\,V = 0$ or $\overline{S} \vee \overline{V} = 1$ {Either the decomposition is uncontrollable or it is unobservable or both}.

This example demonstrates a well known theorem in control theory [14] stating that any state decomposition for a transfer function having a pole-zero cancellation is either uncontrollable or unobservable or both.

EXAMPLE 2

The scenario discussed in this example is a case study about differentiating a perceived problem from a real one [15]. There is a toxic discharge from a chemical plant into a nearby river. Due to a summer drought, the discharge might no longer be sufficiently dilute to be safe to aquatic life. In fact, the discharge is believed to be responsible for an unusually high number of dead fish that in turning up in the river. An engineer is called upon to design a million-dollar waste treatment facility to reduce the toxic chemical concentration by a factor of 10. However, his investigations indicate that dead fish are appearing at the same unusually high rate everywhere, not just downstream of the plant. Let us introduce the propositional variables

T = The plant discharges toxic chemicals into the river,

D = The toxic chemicals flow downstream,

U = The toxic chemicals flow upstream,

N = Fish die downstream,

P = Fish die upstream.

We now test the hypothesis that fish die if and only if there are toxic chemicals. Our premises are

Clausal form	Conditional form
T	$\overline{T}=0$
$T\rightarrow D$	$T\,\overline{D}=0$
$T\rightarrow\overline{U}$	$T\,U=0$
$N\equiv D$	$N\,\overline{D}\vee\overline{N}\,D=0$
$P\equiv U$	$P\,\overline{U}\vee\overline{P}\,U=0$
N	$\overline{N}=0$
P	$\overline{P}=0$

These premises combine to give the function

$$f=\overline{T}\vee T\,\overline{D}\vee T\,U\vee N\,\overline{D}\vee\overline{N}\,D\vee P\,\overline{U}\vee\overline{P}\,U\vee\overline{N}\vee\overline{P} \tag{14}$$

whose complete sum is

$$CS(f)=1\,. \tag{15}$$

Equations (6) and (15) lead to the contradiction that {1 = 0}. These means that the set of premises is inconsistent. There is no way to make all the premises true at the same time. Moreover, the given set of premises validly yields any conclusion, no matter how irrelevant [3]. In the above situation, the remedy for the inconsistency is to discard (at least) one of the given premises. The engineer must abandon the notion that his factory's chemicals are the real fish killer. Further investigations can lead to the real culprit which turns out to be a certain type of fungus in the given scenario [15].

We have deliberately chosen the current example to be a small one, so that the reader might easily convince himself about the existence of inconsistency among the premises by just viewing their verbal statements and without resort to the logic technique. In more sophisticated and involved scenarios, inconsistency within a set of premises is much harder to detect and is intricately concealed and hidden. The engineer cannot usually handle such scenarios bare-handed, but he will hopefully be able to tackle them when armed with the present powerful method.

EXAMPLE 3

Your company is one of two leading companies that are having almost equal market shares for a certain popular product. To obtain a competitive edge over your rival, you want to join arms with three smaller companies X, Y, and Z, so as to form a new consortium of companies or a mega-company. However, your main competitor has exactly the same idea, and plans to establish a similar alliance with three companies A, B, and C which are essentially of similar size, technical expertise, and resources as those of companies A, B, and C. Due to certain market forces government regulations, and conflicts of interests, the following restrictions exist about the participation of the six small companies in the two alliances:

1. If neither A, B, nor C joins the rival alliance, then Y and Z join yours but X does not.
2. If A joins the rival alliance together with either B or C or both, then Y does not join your alliance, and either X does not join it or Z joins it.
3. If B joins your competitors but A does not, or C joins them but B does not, then both X and Y join you, or neither X nor Z does.
4. If C allies with your rival together with A or B or both, or else if neither A nor C joins, then either X does not join you, or Y does but Z does not.
5. If A joins the rival alliance but B does not, then X does not join you or Z does.

Now, we pose the following three questions:

a. In the absence of any information about the participation of companies A, B and C in the rival alliance, what can you conclude about the participation of companies X, Y, and Z in your alliance?

b. You are currently contemplating awarding a contract to one of the X , Y , and Z companies, and you believe that the company awarded that contract is definitely guaranteed to join your alliance. Which company would you choose to maximize participation in your alliance?
c. If you implement the action suggested in (b), and given no further information, what can you conclude about participation of the A, B, and C companies in the rival alliance? Is your alliance bigger than the rival one?

To answer these questions, we formulate the given premises (1) – (5) as follows

Clausal Form	Equational Form
$\overline{A}\,\overline{B}\,\overline{C}$	$\overline{X}\,Y\,Z$
$A(B \vee C)$	$\overline{Y}\,(\overline{X} \vee Z)$
$\overline{A}\,B \vee \overline{B}\,C$	$X\,Y \vee \overline{X}\,\overline{Z}$
$C\,(A \vee B) \vee \overline{A}\,\overline{C}$	$\overline{X} \vee Y\,\overline{Z}$
$A\,\overline{B}$	$\overline{X} \vee Z$

The premises combine into a single equation $f = 0$ where

$$f = \overline{A}\,\overline{B}\,\overline{C}\,(X \vee \overline{Y} \vee \overline{Z}) \vee A(B \vee C)(Y \vee X\,\overline{Z}) \vee (\overline{A}\,B \vee \overline{B}\,C)(X\,\overline{Y} \vee \overline{X}\,Z) \\ \vee (AC \vee BC \vee \overline{A}\,\overline{C})\; X\,(\overline{Y} \vee Z) \vee A\,\overline{B}\,X\,\overline{Z}, \tag{16}$$

The function has the complete sum [4, 12]

$$CS(f) = A\,C\,X \vee A\,X\,\overline{Z} \vee A\,C\,Y \vee A\,\overline{B}\,C\,Z \vee A\,B\,Y \vee \overline{A}\,X\,\overline{Y} \vee C\,X\,\overline{Y} \\ \vee X\,\overline{Y}\,\overline{Z} \vee \overline{A}\,\overline{Y}\,Z \vee \overline{B}\,C\,\overline{Y}\,Z \vee \overline{A}\,C\,\overline{X}\,Z \vee C\,\overline{X}\,Y\,Z \\ \vee \overline{B}\,C\,\overline{X}\,Z \vee \overline{A}\,\overline{B}\,\overline{C}\,X \vee \overline{B}\,\overline{C}\,X\,\overline{Z} \vee \overline{A}\,\overline{B}\,\overline{C}\,\overline{Y} \vee \overline{A}\,\overline{B}\,\overline{C}\,\overline{Z} \\ \vee \overline{A}\,B\,Z \vee B\,C\,X\,Z \vee B\,Y\,Z \vee \overline{A}\,\overline{C}\,X\,Z. \tag{17}$$

In (a) we lack any information about A, B, and C. Therefore, we eliminate the variables A, B, and C by deleting every prime implicant involving A, B, or C from the equation *CS(f)* = 0. This produces the result

$$X\,\overline{Y}\,\overline{Z} = 0, \tag{18}$$

which can be stated in the conditional form

$$X \to Y \vee Z, \tag{19.a}$$

which means that (in the absence of information about the rival participation) if company X joins you, then company Y or company Z or both will also join you. Equation (18) can also be stated in either the equivalent conditional forms

$$\overline{Y} \to \overline{X} \vee Z, \tag{19.b}$$

$$\overline{Z} \to \overline{X} \vee Y\,, \tag{19.c}$$

which we will not explore further since they are not pertinent to the decision requested in question (b). In fact, to answer question (b), let us consider what happens if company Y is selected by assigning the value 1 to Y in (18). This reduces (18) to the identity 0=0, which says that if Y is selected, there will be no information of what will become of X and Z. Similarly, if company Z is selected, we obtain no information about the participation of X and Y. Therefore, it is prudent to award the contract to company X so as to guarantee its participation, since this will trigger the participation of at least one of the two other companies, and hence you get two or three companies joining your alliance. If you grant the contract to either Y or Z, you guarantee the participation of only the single company awarded the contract.

To answer question (c) assuming that your decision in (b) is to ensure the participation of X, we restrict X to the value 1 in (17), to obtain (after the absorption of subsuming terms):

$$\begin{aligned} CS(f) = {} & A\,C \vee A\,\overline{Z} \vee A\,B\,Y \vee \overline{A}\,\overline{Y} \vee C\,\overline{Y} \vee \overline{Y}\,\overline{Z} \vee \overline{A}\,\overline{B}\,\overline{C} \\ & \vee \overline{B}\,\overline{C}\,\overline{Z} \vee \overline{A}\,B\,Z \vee B\,C\,Z \vee B\,Y\,Z \vee \overline{A}\,\overline{C}\,Z. \end{aligned} \tag{20}$$

Now we locate the prime implicants in (20) that involve variables A, B, and C only. This gives us the results

$$AC = 0 \,, \tag{21}$$

$$\overline{A}\,\overline{B}\,\overline{C} = 0 \,, \tag{22}$$

which means that in the absence of any further information, the rival alliance will not be joined simultaneously by A and C, though it will be joined by at least one of the three companies A, B, and C. This means that your competitor recruits one or two companies to join his alliance. Your alliance, however, is joined by two or three companies. Your alliance is most likely bigger than, or at least equal to, your competitor's alliance.

V. CONCLUSIONS

This paper describes the modern syllogistic method, which ferrets out from a given set of premises all the consequents that can be concluded from this set, and casts these consequents in the simplest compact form. The modern syllogistic method can deal with arguments of many varieties on many different topics, but it is restricted herein to engineering subject matter. We believe that the modern syllogistic method can serve as a useful and powerful tool for the engineer, as it can help him reason well and correctly about his specific discipline. Due to space limitations, the paper presents only a quick glimpse of the many possible engineering applications of the method. Notable among the ones excluded here is the application of the method to the resolution of engineering ethical dilemmas, a topic that is covered in a companion paper [16].

REFERENCES

1. Holtzapple, M. T. and W. Dan Reece, 2003, *Foundations of Engineering* (Second Edition), McGraw-Hill, Boston, MA, USA.
2. Al-Maidani, A. H. H. 1993. *Knowledge Constraints and Fundamentals of Deduction and Debating: A Formulation of Logic and Research Fundamentals Compatible with Islamic Ideology*, Darul Qalam, Damascus (*In Arabic*).
3. Copi, I. M. and C. Cohen, 2002. *Introduction to Logic*, (Eleventh Edition), Prentice-Hall, Upper Saddle River, NJ, USA.

4. Brown, F. M. 1990. *Boolean Reasoning: The logic of Boolean equations*, Kluwer Academic Publishers, Boston, MA (Second Edition, 2003, by Dover Publications, Mineola, NY).
5. Gregg, J. R. 1998. Ones and Zeroes: *Digital Circuits and the Logic of Sets*, Wiley, New York, NY, USA.
6. Rushdi, A. M. and A. S., Al-Shehri, 2002, "Logical reasoning and its role in serving security and justice", *Security Research Journal*, Vol. 11, No. 22, pp.114-153 (*In Arabic with an English abstract*).
7. Rushdi, A. M., 2001, "Using variable-entered Karnaugh maps to solve Boolean equations", *International Journal of Computer Mathematics*, Vol. 78, pp. 23-38.
8. Klir, G. J and M. A. Marin, 1969, "New considerations in teaching switching theory", *IEEE Transactions on Education*, Vol. E-12, No. 4, pp. 257-261.
9. Muroga, S., 1979, *Logic Design and Switching Theory*, John Wiley and Sons, New York, NY, USA.
10. Rushdi, A. M. 2001, "Prime-implicant extraction with the aid of the variable-entered Karnaugh map", *Umm Al-Qura University Journal: Science, Medicine and Engineering*, Vol. 13, No. 1, pp. 53-74.
11. Rushdi, A. M. and H. A. Al-Yahya, 2001, "Derivation of the complete sum of a switching function with the aid of the variable-entered Karnaugh map", *King Saud University Journal: Engineering Sciences*, Vol. 13, No. 2, pp. 239-269.
12. Rushdi, A. M. and A. S. Al-Shehri, 2004, "Selective deduction with the aid of the variable-entered Karnaugh maps", *Journal of King Abdul-Aziz University: Engineering Sciences,* Vol. 15**,** No. 2, pp. 21-29.
13. Thayse, A., 1978, "Meet and join derivatives and their use in switching theory", *IEEE Transactions on Computers*, Vol. C-27, No. 7, pp. 713-720.
14. Kuo, B. C., 1995. *Automatic Control Systems* (Seventh edition), John Wiley and Sons, New York, NY, USA.
15. Fogler, H. S., and S. E. Leblanc, 1995, *Strategies for Creative Problem Solving*. Prentice-Hall PTR, Upper Saddle River, NJ, USA.
16. Rushdi, A. M., and A. O. Baz, 2007, "Computer-assisted resolution of engineering ethical dilemmas", SEC7 Paper 147, *Proceedings of the 7th Saudi Engineering Conference (SEC7)*, Riyadh, KSA, Nov. 2007, To appear.