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

Proceedings of the Seventh Saudi Engineering Conference

Riyadh 2-5, December 2007

Volume V

Research and development to serve the industry and upgrade its services

Mechanical Engineering

Industrial 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

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COMPUTER-ASSISTED RESOLUTION OF ENGINEERING ETHICAL DILEMMAS

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ABSTRACT

There are three sorts of complexity involved in engineering ethical situations, namely, problems of vagueness, problems of conflicting reasons, and problems of disagreement. Contemporary engineering practice makes it virtually inevitable that most engineers be confronted with ethical problems or dilemmas during their careers. This paper presents a software package that aids in the resolution of engineering ethical dilemmas. The utility of the package is demonstrated by discussing its logic in handling some classical engineering dilemmas.

KEY WORDS

Engineering practice, Ethical dilemmas, Decision analysis, Logic deduction and induction, Statistical analysis, Relational databases.

1. INTRODUCTION

Professionals can be defined by three characteristics: they are experts, they use their expertise responsibly, and they collectively identify themselves as such. A professional "professes" his membership in a distinguished group. A significant goal of professionalism is efficiency, because it reduces the effort needed by an ordinary person to identify responsible experts. Professional status normally develops around occupations in which it is hard to know that a person is incompetent until it is too late. Engineering clearly calls for professionalism, because serious defects in an engineer's work may not become evident until years after the work is completed [1].

Professional obligations are usually summed up in a professional code of ethics [2-4]. The task of a code of ethics is not to derive obligations from first principles, but to spell out what the public expects from the profession. A profession

is defined primarily by its reputation, because it exists precisely to create a reputation. An engineer's professional obligation is fairly well defined. It is to live up to the expectations the profession has created. The public expects a building, for example, to be totally safe from collapse except in the case of extraordinary disaster. Contemporary engineering practice makes it virtually inevitable that most engineers be confronted with ethical dilemmas during their careers. Indeed, this is true of all professionals, including physicians, lawyers, and teachers.

Ethical dilemmas are situations in which two or more ethical obligations, duties, rights, goods, or ideals come into conflict with one another, and it appears that not all of them can be fully respected. It is also possible for one ethical principle to have two or more incompatible applications in a given situation. There are at least three sorts of complexity involved in certain situations that cause ethical dilemmas [4].

First, there are problems of **vagueness**. It may be unclear to individuals which, if any, ethical considerations or principles apply to their situation. There are always troublesome cases where there is considerable vagueness about whether a "gift" is an innocent amenity or an unacceptable bribe.

Second, and more frequently, there are problems of **conflicting reasons**. It may be perfectly clear which ethical principles apply to one's situation. The difficulty instead might be that two or more clearly applicable ethical principles come into conflict (or that one principle seems to point simultaneously in two different directions).

Third, there are problems of **disagreement**. Reasonable and responsible individuals and groups may disagree about how to interpret, apply, and balance ethical reasons in particular situations. This disagreement becomes even more complicated within engineering corporations in which individuals must work together within authority-structured relationships.

The problems of vagueness, conflicting reasons, and disagreement suggest the need for several steps in approaching dilemmas. The steps are distinct, even though they are interrelated and can often be taken jointly [4]:

1. Identify the relevant ethical factors and reasons. What are the conflicting responsibilities, competing rights, and clashing ideals involved?

2. Gather all available facts that are pertinent to the ethical factors involved.

3. If possible, rank the ethical considerations in order of importance as they apply to the situation (Sometimes this is not possible, and the goal is to find a way to meet equally urgent responsibilities and to promote equally important ideals).

4. Consider alternative courses of action as ways of resolving the dilemma, tracing the full implications of each (Typically this involves making factual inquiries).

5. Talk with colleagues or friends, seeking their suggestions and alternative perspectives on the dilemma.

6. Arrive at a carefully reasoned judgment by weighing all the relevant ethical factors and reasons in light of the facts (This last step is the most difficult!).

The study of engineering ethics helps develop skills that are useful at all these stages. By combining readings on ethical theory with case studies, classroom discussion, and clarification through writing, it is possible to strengthen skills in ethical reasoning [2-4].

The main contribution of this paper is to introduce a computer package that aids the problem solvers in solving engineering ethical dilemmas. The package consists of several modules that the user can utilize in making an informed or educated decision concerning the dilemma he or she faces. The first module offers useful templates for implementing the famous Kepner-Tregoe Decision Analysis (KTDA) by establishing mandatory measurable criteria (musts) and optional measurable ones (wants) by which to rank the possible alternative solutions. Furthermore, the alternatives are also ranked according to their adverse consequences or undesirable effects. The second module is one of logic deduction which implements the modern syllogistic algorithm. This algorithm does not add new information but it ferrets out, from a given set of premises, all that can be concluded in the simplest possible form (including information that was originally hidden within the premises). This is accompanied by a module on logic induction which assists the user in utilizing Mill's rules for extending and augmenting his or her knowledge in a plausible but cautious manner. The results of logic induction should not be taken for granted, but must be treated as possible hypotheses or conjectures that are still in need of some kind of proof or supporting test. The fourth module attempts to make use of the fact that collective opinions (especially experts' opinions) are never inferior to individual ones. This module handles a dilemma by addressing meaningful questionnaires to pertinent groups of engineers, and attempting to extract significant statistical information from the data collected. The fifth and last module is a relational database, from which the user can access many useful tutorials, engineering codes of ethics, general and specific rules of Islamic jurisprudence, and pertinent case studies

The remainder of this paper is organized as follows. Section 2 reviews certain contemporary engineering ethical dilemmas. Section 3 classifies the modules of the present software package that aids in the resolution of engineering ethical dilemmas, while section 4 offers two examples of ethical reasoning. Section 5 discusses the package implementation and features, and section 6 concludes the paper.

2. EXAMPLES OF ENGINEERING ETHICAL DILEMMAS

The literature on engineering ethics deals with a multitude of important issues and cases dealing with such entities as honesty, integrity, truthfulness, and trustworthiness of the engineer, and his moral responsibilities towards himself, his employer, his coworkers and his community in addition to his environmental and global responsibilities [4]. Due to space limitations, we cite below only a few examples of workplace responsibilities.

2.1. Whistle-Blowing:

If an engineer decides that the current practice of his company is unethical, there are at least three basic responses: (a) "blow the whistle," either internally or publicly, (b) resign, or (c) keep quiet and do what the company wants. Although prudential issues must be distinguished from ethical ones the would-be whistleblower must think carefully before acting since he often pays a substantial price, and his effectiveness is not guaranteed [1, 4].

2. 2. Ownership of Intellectual Property:

Intellectual property includes patented inventions, trade secrets, or copyrighted material. An employer normally owns any invention or trade secret conceived by an inventor who is working "for hire." It is not always obvious who is working for hire. A full-time employee of a business or government agency almost always is, whereas a consultant or a Ph.D. student may not be. One cannot have property rights to anything that occurs in nature, but is it possible to patent a genetically altered organism. As technology-based systems grew, businesses pressed for rights over intellectual property in order to provide an incentive to innovate. However, there is a recognition that pure ideas must be allowed to circulate without commercial restraint. Many people argue that traditional knowledge of healing and agriculture, like knowledge of mathematics, are part of our common human heritage and should not be subject to commercialization.

2.3. International Business Ethics:

In a global economy, engineering projects are often international. They bring together people from different traditions who have different values and do business in different ways. Engineers working abroad (or at home!) may encounter cronyism, nepotism, kickbacks, and bribes. A kickback means that a representative of a potential supplier offers the purchasing agent for a company or government a side payment in exchange for a contract. Though this is definitely unethical, besides being illegal and punishable in most countries, it is business as usual in some other countries. Cronyism takes place in much of the world, where one routinely lets contracts go to one's friends; citing the reason that business is based on trust relationships with individuals. Some people even claim that cronyism is not immoral since it provides the social glue that makes business possible and that reflects a highly developed moral sensibility [1, 4].

3. PACKAGE CONTENTS

The main contribution of this paper is to introduce a computer package that aids the problem solvers in solving engineering ethical dilemmas. Some brief information about the modules of the package is given in the following subsections.

3.1 Decision analysis:

The package has a module implementing an algorithm due to Kepner and Tregoe for Decision Analysis (KTDA) [5-6]. The KTDA algorithm selects the "best" alternative among several alternatives, by making a quantitative comparison among these alternatives according to two categories of criteria: mandatory measurable criteria (musts) and optional measurable ones (wants). A final review and evaluation follows through a consideration of the adverse consequences of a few top alternatives.

3.2 Logic Deduction:

The package includes a module implementing the modern syllogistic algorithm for formal logic deduction [7-9]. This algorithm starts with a set of premises, converts it to a single Boolean equation in the form of $f = 0$, computes the complete sum CS(f) of the function f [10-11], and ends with a set of consequents. Thereby, the algorithm ferrets out any (and all) information hidden within the premises. In fact, the algorithm 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). If any implicant (whether it is prime or not) of f is equated to 0, then the result is a true consequence (albeit not necessarily in the most compact form). 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.

3.3 Logic Induction:

Scientific logic has two distinctive branches: deduction and induction [12]. To a first approximation, deduction is arguing from the general to the particular, whereas induction is arguing from the particular to the general. In a deductive argument, the conclusion follows necessarily from the premises. In an inductive argument, the conclusion follows probably from the premises. Deductive arguments are judged as valid or invalid by a black-or-white standard: in a valid deductive argument, if the premises are true, then the conclusion must be true. Inductive arguments are judged as strong or weak according to the likelihood that true premises imply a correct conclusion. Both deductive and inductive arguments are evaluated in a two-step procedure: (a) Does the conclusion follow from the premises? and (b) Are the premises true? The order of attacking the two questions is arbitrary; usually one considers first whichever of the two appears to be dubious. Both deduction and induction are necessary and complementary aspects of inference. Theoreticians value deduction and empiricists value induction, but the choice is based on taste rather than inherent superiority.

In summary, we note that while in deduction true premises do necessitate the conclusions, in induction the premises do not necessitate the conclusions but only give grounds for them. Both processes are used constantly in research. By observation of events (induction) and from principles already known (deduction), new hypotheses are formulated; the hypotheses are tested by applications. If the results of the tests satisfy the conditions of the hypotheses, laws are arrived at—by induction; from these laws future results may be determined by deduction.

The package includes a tutorial module on various heuristics that can aid in inducing information from a set of premises. Notable among these heuristics, are the well known Mill's canons which include the Method of Agreement, the Method of Difference, the Joint Method of Agreement and Difference, the Method of Concomitant Variations and the Method of Residues [12].

3.4 Statistical Inference:

Prudent judgment of a dilemma may be obtained by presenting questionnaires to a set of interested and knowledgeable persons who can range from prominent scholars to laypersons. The package contains a module to study the opinions of such people from a statistical point of view.

3.5 Tutoring and Bookkeeping:

The package contains some tutorial material about ethical dilemmas and how to resolve them. It encompasses a relational database that has three distinctive parts. The first one includes a set of rules of Islamic jurisprudence, together with some explanation and examples. The second part has cross-referenced codes of ethics of international professional and engineering societies. The third part has classified sets of pertinent case studies together with a list of addresses for many helpful websites.

4. EXAMPLES OF ETHICAL REASONING

4.1 Example of Reasoning via Logic Deduction:

A dishonest government employee would not grant work to a consulting engineer unless he pays him a bribe. Is it ethical for the consultant to pay the bribe so as to be awarded work? Let us define the propositions:

   W = The employee awards work to the consultant,
   D = The consultant deserves to be granted work,
   H = The employee is honest and would not ask for a bribe to allocate work appropriately,
   E = The behavior of the consultant is ethical,
   B = The consultant bribes the employee.

The situation above is described by the premises H', W, $H \rightarrow (W \equiv D)$, $H' \rightarrow (W \equiv B)$, $W' \rightarrow E$, $WD \rightarrow E$, $WD' \rightarrow E'$, $DB' \rightarrow W'$, and $B \rightarrow W$, which can be combined into the single function f (equal to 0), where

$$f = H \vee W' \vee H(WD' \vee W'D) \vee H'(W\,B' \vee W'B) \vee W'E' \vee WDE' \vee WD'E \vee DB'W \vee BW', \tag{1}$$

from which we obtain

$$CS(f) = H \vee W' \vee B' \vee DE' \vee D'E = 0, \tag{2}$$

and hence

$$H = W' = B' = DE' = D'E = 0, \tag{3}$$

which says that the employee is dishonest and that he is receiving a bribe from the consultant while granting him work. It also says that the behavior of the consultant is ethical if and only if he deserves to be granted work.

This conclusion is in agreement with dominant Islamic jurisprudence, according to which the prohibition of bribery is relaxed for a person who cannot find an alternative means to acquire his just rights. However, persons with superior moral characters, (especially those looked upon by society as leaders or examples to be followed) should refrain from using the above special permission whatever the circumstances are. For those, we must add the premise $(B \rightarrow E')$, so that equation (2) is replaced by

$$CS(f) = W' \vee B' \vee E \vee D = 0, \tag{4}$$

i.e., under these circumstances, the action of paying a bribe to secure work is definitely unethical and the work awarded through bribery is necessarily undeserved.

Of course, the answers above might differ if the issue is considered from the legal rather than the ethical point of view. It might also be more prudent for the consultant to explore other possible actions (other than just to pay or not to pay the bribe). For example, he might report the matter to the concerned authorities and help them catch and convict the employee.

4.2 Example of Reasoning via Logic Induction:

The method of residues can be schematized as follows [12]

A, B occur together with x, y.

B is associated with y.

Therefore, A is associated with x.

A customer wants to (a) do some ordinary clean business with a certain company, and (b) to steal a trade secret of this company. To achieve these disparate purposes he offers "gifts" to two employees A and B of the company. He presents employee A with a small token such as an expensive ballpoint pen. For employee B he proposes to offer two fully-paid round-trip tickets to the Maldives together with full accommodation for a couple of weeks at a 5-star hotel there. It is clear that employee A is the one to help with innocent usual business. Given the above information, employee B can use the method of residues to conclude that in return for the "gift" he receives he is expected to betray his employer by revealing a trade secret to an adversary.

5. PACKAGE IMPLEMENTATION AND FEATURES

The software package was implemented by using a database system that was required to be (a) capable of handling huge data and also providing fast data manipulations, (b) using a relational database, (c) platform independent, (d) highly protected against malicious software and (e) easily administrated and not expensive to operate. The selected system is the Oracle database which provides all the aforementioned requirements. The associated development tool is the Oracle developer, which is compatible with the Oracle database, modular, and scaleable for future development.

Due to space limitations, we will only give the reader a quick glimpse about the features and capabilities of our package. Figure 1 demonstrates the first part of KTDA of an ethical problem of whistle-blowing. Figure 2 is a sample of the help offered by the database in compiling rules of Islamic jurisprudence.

Decision Analysis Definition

Problem Statement	An engineer discovers that his factory is endangering the public health by discharging a certain pollutant to a nearly lake. He has four alternatives to choose from. (1) blow the whistle, inform those concerned, and possibly get fired and sued by his company. (2) warn his superiors within the company through regular channels. (3) keep silent, and continue to work for the company. (4) keep silent, and resign.						
Alternatives		**1**		**2**		**3**	**4**
Musts	Observing ethical responsibility towards public safety.	GO		GO		NO GO	NO GO
Wants		**Weight**	**Rating**	**Score**	**Rating**	**Score**	
1. Avoiding getting into trouble.		8	2	16	8	64	
2. Retaining job.		6	4	24	8	48	
3. Feeling good about oneself.		10	8	80	6	60	
				120		172	

Fig. 1. A Typical form for KTDA.

Fig. 2. A Sample of the help form displaying a rule of Islamic jurisprudence.

6. CONCLUSIONS

This paper presents a software package that aids in the resolution of engineering ethical dilemmas. The package consists of several modules that the user can utilize in making an informed or educated decision concerning the dilemma he or she faces. Needless to say, the package only assists the user in resolving a dilemma, and does not do the required resolution by itself. The package includes implementations of all algorithmic parts of the resolution process, and offers guidelines or help for its heuristic nonalgorithmic parts.

Though the main theme of this paper is the resolution of ethical engineering dilemmas, it has a very important offshoot. The paper demonstrates how deductive and inductive logics can play complementary rather than competing roles in ethical reasoning.

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