The UMAP Journal

The Journal of Undergraduate Mathematics and Its Applications

Results of the 2005 Interdisciplinary Contest In Modeling
page 115

COMAP

Summer 2005 **2**

Judge's Commentary: The Outstanding Exhaustible Resource Papers

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Introduction

The Interdisciplinary Contest in Modeling (ICM) provides an exciting and competitive environment for time-constrained innovative thinking. The judging of the papers was accomplished by several stages of review, culminating with a final set of papers that were reviewed for placement in the top two categories of Outstanding Winners and Meritorious Winners. Consequently, each paper ranked in the top two categories was refereed by at least 7 reviewers.

This year's ICM problem examined the eventual depletion of a nonrenewable or exhaustible resource, with the team selecting the resource to be analyzed. Consequently, several different topics were considered, ranging from oil resources to the availability of lumber, among other topics. Participating teams prepared several exciting investigations that demonstrated innovative thinking and good topic research into the underpinnings of the resource selected. To rank the contributions across the many selected topics analyzed, judges assessed the following qualities:

Summary: Adequacy of the one-page summary in describing the paper, its results, and its methodology. The summary was deemed to be a very important factor in the overall paper's scoring.

Science: Thoroughness of research into the literature regarding the nature and handling of the selected resource, alternatives to the subject resource, and new technology in increasing use efficiency or providing alternatives.

The UMAP Journal 26 (2) (2005) 175–178.

Modeling: Assumptions used, documentation of assumed parameter values, appropriateness of the governing mathematical equations, and conceptual model construct.

Analysis: Adequacy of model calibration to historic data and trends, analysis of model strengths and weaknesses, sensitivity analysis of modeling components, variations in modeling predictions due to changes in various types of society reactions to continuing depletion of resource.

Presentation: Quality of report text, graphics, and mathematical development. Clarity in paper presentation. Use of proper references and citations.

Each judge independently scored each paper on these qualities and then determined an overall score. There was little variability among judges' scores. A large majority of the papers demonstrated an in-depth investigation of the selected resource, and frequently innovative thinking was applied towards solving the resulting governing mathematical equations. The judges were uniformly impressed with the quality of research presented in the papers and the amount of work achieved in the very short time frame.

The Problem

The 2005 ICM Problem considered a highly relevant issue, the fate of a nonrenewable or exhaustible resource, with the problem incorporating linkages of consumption to economic, political, environmental, security, demographic, emerging technologies, and other factors. The first task for a participating team was to choose a resource and to understand the underpinnings of its nature and interdependencies on the factors that affect its rate of consumption. For example, such a resource typically has associated alternatives which, although possibly more expensive to utilize, could extend the life of the resource.

Oil was the most popular resource selected among the teams. Other resources considered included potable water, lumber, natural gas, minerals, uranium, and living space.

Modeling Approach

Ideally, once a conceptual model of supply and demand is developed and calibrated to the history of discovery, development, and consumption, the model can be used to predict the future of the resource under various conditions. Teams also did research on emerging technologies that provide alternatives or more efficient use of the resource. Using historical data, teams used regression to assess demand and supply trends.

Teams typically noted that the historic consumption trend was increasing with time and at an increasing rate. The recommended mathematical analogs were typically of the exponential type with parameters calibrated by a least-squares fit to data. Interestingly, although teams considered different resources the resulting mathematical equations tended to be similar.

Many teams examined world population trends and developed relationships between resource consumption and world population. They paid little attention, however, to the resource-relevant distribution of the population growth; most consumption has occurred in developed nations, which have a different population growth trend than developing countries do. In any case, teams readily noted that at some point demand will exceed supply. For oil, this "undersupply" was estimated to occur between 2015 to 2050.

Many teams went no further; they did not focus on how their model's predictions would change under different global conditions and reactions to decreasing availability of the resource. In other words, they assumed that the future will reflect the past and that the world will not react to decreasing availability of the resource. However, a few teams did examine global influences on their model. For example, one team quantified the effects of an oil embargo by correlating the impacts of past embargos on oil consumption.

Many teams researched their resource and investigated alternatives methods to improve efficiency. Probably due to the limited time frame, however, they paid little attention to modeling the effect of implementation of these alternatives or efficiency improvements in delaying a possible "undersupply point in time."

Presentation of Results

The judges were impressed with the hard work that went into the paper write-ups. Excellent graphs and presentation of equations were typical. However, the presentation of the model development and modeling results varied greatly. In a few cases, the equations presented were not appropriate for the model description in the text of the paper; possibly, these incidents were simply carelessness or typographical errors. The top-ranked papers were of the highest quality in research into the literature, development of the mathematical model, approximation or solution of the governing equations, analysis of the recommended model, and presentation of the results.

Conclusions and Recommendations

For myself, being involved with the review and judging of the 2005 ICM Problem was an enjoyable experience. The judging demonstrated to me once again the continuing potential for young people to absorb new technology and to accept challenges to improve themselves by independent work. It gives me comfort to know that perhaps a few of the 2005 ICM Problem teams will be interested and challenged by this very relevant problem, and may one day discover new technology or policies that will postpone the so-called "undersupply point in time," or find an alternative technology that does not use nonrenewable or exhaustible resources.

The following are recommendations for future ICM Problem solvers:

- Write-ups: Check your equations to avoid a typographical error resulting in a relationship that is inconsistent with the relevant written description.
- Clearly state modeling assumptions and their limitations, and cite references to justify specific choices (such as ranges for modeling parameter values).
- Provide a relevant list of references that are clearly used in the text. Don't list references that you don't cite in the report.
- Do sensitivity testing of your model and discuss your testing results.
- Evaluate your modeling results and discuss their implications. If your results agree with the literature, say so and cite references; if not, state the disagreement and cite references.
- Double-check your grammar and do a spell-check of the report.

About the Author

Ted Hromadka II has three Ph.D. degrees, in the fields of applied mathematics, civil engineering (water resources emphasis), and advanced computational modeling. He is a Certified Hydrologist in both surface and groundwater, a registered civil engineer in the States of California, Nevada, Arizona and Hawaii, and a licensed Geoscientist in the State of Texas. His background includes concurrently holding both academic and consulting positions since 1973, with positions such as Research Hydrologist at the USGS, Research Associate at Princeton University, and Professor in the Departments of Mathematics, Geological Sciences, and Environmental Studies at California State University, Emeritus. He currently holds an adjunct position at the Wessex Institute of Technology, England, and is a Principal Hydrologist at the consulting firm Hromadka & Associates. Prior to this position, Dr. Hromadka founded and was Practice Director of the Hydrology & Atmospheric Sciences practice at Exponent Failure Analysis & Associates. You can learn more about Ted at `http://www.hromadka.net`.

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Vol. 26, No. 2 2005

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