

THURSDAY  
FEBRUARY 19, 2004

Scaife Hall Auditorium  
Room 125

4:00 PM  
Refreshments—3:30 PM



### Dr. Offer Shai

*TEL-AVIV UNIVERSITY  
DEPARTMENT OF MECHANICS,  
MATERIALS AND SYSTEMS*

**Offer Shai** received his Ph.D. (Summa Cum Laude) in Mechanical Engineering from Ben-Gurion University, Israel in 1997, and he is currently a faculty member in the Department of Mechanics, Materials and Systems at Tel-Aviv University. His scientific background is comprised of several diverse academic fields—mechanical engineering, computer science, advanced discrete mathematics, and operations research—and includes six years as an engineer with the Israel Defense Forces (IDF). This combination of both theoretical and practical training and experience enables Dr. Shai to conduct research in a variety of scientific fields: combinatorial engineering representations, machine theory, artificial intelligence, structural mechanics, integrated engineering systems, combinatorial optimization, and conceptual design and creativity. The main objective of his research program is to develop methodologies for transforming engineering knowledge through combinatorial representations for both analysis and design. This work has yielded promising results, both theoretical and practical, and has attracted the interest and funding from the industry.

*For more information:*

<http://www.ece.cmu.edu/seminar/index.php>

James C. Hoe, ECE Seminar Host  
[jhoe@ece.cmu.edu](mailto:jhoe@ece.cmu.edu)

## TRANSFORMING ENGINEERING KNOWLEDGE THROUGH COMBINATORIAL REPRESENTATIONS FOR DESIGN, ANALYSIS, AND THEORETICAL RESEARCH

In the work presented in this talk, different general discrete mathematical models were developed. These are termed combinatorial representations. In this talk, I will introduce only the representations based on graph theory: graph representations.

This research is intended to represent the engineering problem through one of the graph representations, then, through a series of transformations between the graph representations, to transform it to another engineering domain, where it is solved.

This approach enables the knowledge existing in the transformed domain to be employed in the representations and their interrelations. In this talk, I will introduce a number of practical results that were achieved by employing these graph representations:

**Revealing new relations between different engineering disciplines.** Taking advantage of the relations between the representations has led to the establishment of a number of essential relations and transformations between different engineering domains.

**Treating integrated systems in a unified way.** The approach allows dealing with highly coupled systems containing elements from different engineering domains, while the analysis process in the representations is applied to all the engineering elements disregarding their original domain. This enables a new type of collaboration between engineers from different fields.

**Deriving methods, theorems, concepts and ideas.** Both known and new theorems and methods in one engineering domain can be transformed to other domains through the relations between the representations. This theoretical research will be demonstrated by introducing transformation of knowledge in the same field (such as, transformation between machine theory and structural mechanics), and between different fields (such as, between electronics and mechanics).

**Developing conceptual design methods.** The ability to transform engineering designs from one engineering domain to the other through these representations has yielded new techniques for conceptual design. This work has already been applied to solve practical design problems and the results will be introduced in the talk. In addition, this approach opens up a way to predict the size of the "domain of concepts" through knowledge existing in other domains.

There are additional applications of this approach, but in this talk I will introduce only one – a novel methodology for engineering education. According to this methodology, students first learn the general mathematical models and only then, on the basis of their knowledge of these representations, do they learn the engineering material.