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RESEARCH AREAS

A PRESCRIPTIVE MODEL OF THE CONCEPTUAL ENGINEERING DESIGN PROCESS BASED ON PARAMETER ANALYSIS AND C-K THEORY

Ehud Kroll and **Gil Weisbrod** (Technion–Israel Institute of Technology)

The objective of this research is to propose a new prescriptive model for conceptual engineering design based on a methodology called Parameter Analysis and a relatively new descriptive model called C-K Theory. Parameter Analysis began in the 1970s at MIT as a training methodology for innovators, and has developed over the last 20 years into a prescriptive model with clear and distinct steps. These steps lead the designer through the process of starting with a rough idea and turning it into an elaborate conceptual design of a realizable product. Parameter Analysis, however, lacks in not having a strong theoretical foundation, so it is difficult to establish its "correctness" and its relation to other design methodologies and tools. C-K Theory has gained a reputation for being a very general descriptive model of the design process, encompassing everything from the initial need statement, through generation of new scientific knowledge, to yielding breakthrough designs. It seems especially suitable for capturing highly innovative design processes. C-K Theory, however, lacks in its prescriptive aspect: it can explain the activities during design, but does not guide the designer as to what to do next at any given moment. This research, therefore, studies Parameter Analysis in light of C-K Theory and vice versa, using a multitude of case studies in which both models have been and will be applied. The goal is to generate a new prescriptive model of conceptual engineering design that includes the benefits of both Parameter Analysis and C-K Theory. The object is to obtain a model comprising a clear and concise step-by-step procedure that is conducive to teaching and practicing design,

and at the same time, rooted in a theoretical foundation to support its scientific validity and allow comparison with other design models. The expected significance of this research is the contribution to the theory and practice of engineering design, eventually leading to improved design processes and better designed products.

Keywords: Conceptual design, parameter analysis, C-K theory

ABDUCTION IN DESIGN

Ehud Kroll and **Lauri Koskela** (University of Huddersfield, UK)

The pragmatist philosopher Peirce defined abduction as the only type of inference capable of producing a new idea. Influenced by Peirce's seminal writings and subsequent treatments on abduction in the philosophy of science, over the last 40 years, design scholars have endeavored to shed light on design by means of the concept of abduction. A review and an evaluation of the related literature, however, suggest that research into abduction in design is still undeveloped. This research shows gaps in coverage, lack of depth, and diverging outcomes. The difficulties at hand may be the cause of this situation: diverging developments of the concept of abduction in the philosophy of science, the differences in context between science and design, and the embryonic state of the science of design itself. By focusing on the differences between science and design as well as empirical knowledge of different phenomena comprising design, new conceptions of abduction in design are derived. Given the differences of context, proponents contend that abduction in design can show characteristics not found or still unidentified in science. Design abduction may emerge in any part of the design process. Abduction can occur in connection to practically all inference types in design. It is a property of an inference besides being an inference itself. Abduction usually leads to an idea new to the context. The main criterion of an abducted insight in design is its utility. A number of the most important abductive inference types as they occur in design are studied in more detail, thus covering regressive inferences, composition, transformation, manipulative abduction, decomposition, analogical reasoning, and invention of requirements.

Keywords: Abduction, innovative abduction, design reasoning

MULTI-OBJECTIVE GAMES

Erella Eisenstadt, Gideon Avigad, and Amiram Moshaiov (Tel Aviv University)

This research focuses on the applications of evolutionary and co-evolutionary algorithms for solving multi-objective games under undecided objective preferences.

Keywords: Optimization, evolutionary computation, multi-criteria decision making

DYNAMIC MIMICKING

Avi Weiss and Uri Ben Hanan

Research and development of a robot capable of transporting a wheelchair over obstacles, utilizing the chair's own user interface to drive the robot. Patented.

Keywords: Wheelchair dynamics, robotics, maneuverability

INVERSE GROUND EFFECT ON A DOWNWARD THRUSTING PROPELLER

Avi Weiss and Ayelet Goldstein

While developing a wall-climbing robot utilizing downward thrust propellers for increasing traction, a decrease in thrust was discovered when propellers get close to the ground. Whereas ground effect usually increases lift, in this case we observe the opposite phenomenon, which has not yet been investigated. Initial experimental work shows that increasing the distance of the propellers from the ground increases the thrust.

Keywords: Climbing robot, ground effect

FRICTION STIR WELDING (FSW)

Michael Regev and **Stefano Spigarelli** (Università Politecnica delle Marche, Ancona, Italy)

Because friction stir welding (FSW) is a non-fusion welding process, it has many advantages over conventional welding processes. Among these advantages are the elimination of hot and cold cracking and the ability to join non-weldable alloys. The processes of welding AZ31B to other alloys; e.g. AA6061, as well as welding AA2024, are studied together with the creep properties of the weld.

Keywords: Friction stir welding, aluminum alloys, AA6061, AA2024

FRICTION STIR PROCESSING (FSP)

Michael Regev and **Stefano Spigarelli** (Università Politecnica delle Marche, Ancona, Italy)

Friction Stir Processing (FSP) is a severe plastic deformation process derived from Friction Stir Welding (FSW). The aim of FSP is to obtain a stir zone with very fine grain size. As in FSW, in FSP a non-consumable rotating tool with a shoulder and a pin traverses the parent material and produces intense plastic deformation. The 2024 (Al-4%Cu-1.5%Mg) aluminum alloy is one of the most widely used materials for airplane structures and as such has been investigated in depth to clarify the relationships between its microstructure and its mechanical properties. Unlike the case of FSW of the 2024 aluminum alloy, very few publications have investigated FSP of the 2024 aluminum alloy. The current research deals with the microstructure development of AA22024 during FSP.

Keywords: Friction stir processing, aluminum alloys, AA2024

Mg-BASED AMORPHOUS ALLOYS

Michael Regev and **Alexander Katz-Demyanetz** (Technion–Israel Institute of Technology)

Crystalline magnesium alloys are attractive due to their high strength-to-weight ratio. In addition, amorphous alloys offer high corrosion resistance and good mechanical properties. One drawback of amorphous alloys is the high cooling rates required to achieve an amorphous microstructure. Ongoing research in this area, therefore, focuses on the development of amorphous alloys that can be cast by conventional processes. Special attention is paid to the microstructure characterization by using advanced characterization tools such as High Resolution Transmission Electron Microscopy (HRTEM).

Keywords: Metallic glass, melt spinning, amorphization

MICROSTRUCTURE AND MECHANICAL PROPERTIES OF $Ta_{20}Nb_{20}Hf_{20}Zr_{20}Ti_{20}$ HIGH ENTROPY ALLOY

Michael Regev and **Alexander Katz-Demyanetz** (Technion–Israel Institute of Technology)

Because modern jet engines require larger and larger parameters, improved creep properties are essential for the aerospace industry. The currently used Ni-based superalloys are reaching their limits, and since the beginning of the 21st century new alloys known as High Entropy Alloys (HEAs) have begun to look attractive. HEAs can be regarded as solid solution alloys that contain at least five alloying elements in equal or near equal atomic percentages, and this large number of alloying elements results in maximizing the configurational entropy of the disordered solid solution. However, the microstructure of certain HEAs can include nano-precipitates, ordered solid-solution phases, disordered solid-solution phases, and even amorphous phases. Among the various systems of alloying elements studied, the $Ta_{20}Nb_{20}Hf_{20}Zr_{20}Ti_{20}$ alloy seems to be attractive due to its reduced density of 9.94 g/cm^3.

Keywords: High entropy alloys, $Ta_{20}Nb_{20}Hf_{20}Zr_{20}Ti_{20}$

DRILLING IN ALUMINUM ALLOYS

Michael Regev and **Uri Ben-Hanan**

The inner surface of holes drilled in AA2024 is investigated to find a correlation between the drilling parameters, microstructure changes, force measurements, and acoustic emission.

Keywords: Drilling, aluminum alloys, microstructure, AA2024

AUTOMATIC ADAPTIVE-CALIBRATION OF ACOUSTIC CHAMBER

Avi Weiss and Roee Diamant (Haifa University)

An acoustic chamber needs to isolate sounds produced inside the chamber and reduce sound reflections. The material used to cover the chamber affects these reflection properties. However, different material shapes provide better reflection reduction for different sound frequencies. Thus, for different frequencies, different chambers are used. This research examines a method to actively change the shape of the material, based on the sound frequency produced in the chamber.

Keywords: Acoustic chamber, acoustic reflections, adaptive shape change

MINIATURE AUTONOMOUS JUMPING ROBOT

Uri Ben-Hanan, Avi Weiss, Valentin Zaitsev, Gabor Kosa (Tel Aviv University), and Amir Ayali (Tel Aviv University)

Research and development of a prototype of a tiny robot (~25g) that can jump over a height of 3.5m, glide, and allow control of its direction.

Keywords: Bio-inspired robotics, jumping robot, gliding robot

MINIATURE CLAMPING SYSTEM

Uri Ben Hanan, Avi Weiss, Rafi Wertheim, and Efi Kashani

Manufacturing small parts of only a few millimeters in size may require accuracy in the order of one micrometer. This leads, in turn, to difficulties while taking out the workpiece from the processing machine for measurements or other operations and positioning it back in its exact place afterwards for further processing. In this research project, a three-fingered small chuck is developed. A linear piezo-motor moves the fingers while a force sensor is installed at the end of each one. A special algorithm was developed that enables moving the workpiece in the XY plane while maintaining constant holding forces. Four partners are working on this research project. A-Form AG, a German company producing small injection molds, is the end user of the current research project. Fraunhofer IWU, a research institute, is developing the image processing system for recognizing the position of the workpiece. This system is designed to take a picture of the workpiece prior to removing it from the processing machine and another picture after remounting it, such that any non-desirable displacement of the workpiece will be compensated by the motion system developed by the ORT Braude team. The fourth partner is the Israeli company, H. Azaria PAL Ltd., which specializes in producing high accuracy chucks for processing accurate parts, and is involved in the mechanical design and production of the new smart clamp system. The research project is part of the EUREKA program and is supported by the Israeli Innovation Authority.

Keywords: Small parts manufacturing, accurate positioning and orientation, manufacturing dynamics

COOPERATION OF INVERTED PENDULUM ROBOTS

Uri Ben-Hanan and Avi Weiss

Inverted pendulum robots are highly maneuverable; however, they are very limited when encountering obstacles. We are examining the possibility of getting two (or more) such robots to join together so that they can traverse obstacles. The project deals with the design issues of the robots, communication between the robots to find one another, and the mechanism and algorithm of autonomous connection.

Keywords: Kinematics, dynamics, control, mobile robots, robot cooperation

DEVELOPMENT OF CUTTING FORCE AND CUTTING POWER PREDICTION PROGRAM BY FINITE ELEMENT METHOD (FEM) AND EXPERIMENTAL INVESTIGATION FOR PREDICTING CUTTING ZONE TEMPERATURE IN MICRO END MILLING MACHINING OF METALS

Yitzchak Yifrach and **Mor Elgarisi**

Most of the energy of machining that passes from the cutting tool to the raw material (cutting zone) is transformed into heat. The heat transfer from the cutting zone depends on the thermal properties of the raw material and on its configuration. The temperature rise of the cutting zone may limit the cutting speed and the cutting depth, causing tool wear and limiting its life, and creating thermal stress in the raw material and distortions of its surface quality.

It is therefore highly desirable to predict the cutting zone temperature and relate it to the cutting performance parameters (depth of cut, cutting velocity, feed, linear speed of cutting progress, power required, and specific cutting energy). Due to the nature of metal cutting, it is very difficult and very expensive to measure temperature directly in the cutting zone.

A controlled end milling experiment was compared with a mechanical finite element model (FEM), simulating the actual cutting force distributions and other effects occurring in the cutting zone. Electric milling was controlled by [LabVIEW] software, keeping the torque and rotational speed constant and preventing disruption of fixed air flow. As a reference for the mechanical model, this research conducts end milling experiments with the material Aluminum 6061-T6

To build a reliable mechanical machining model that obviates the need for physical pre-tests, one needs to know, among other things, the cutting power that is transferred from the cutting tool to the raw material. This research shows how to predict the cutting power during machining by finite element analysis (FEA). The cutting power was arrived at indirectly through calculations of the cutting forces that developed during machining (end milling) in the cutting zone at the steady state.

The mechanical model results showed that the actual cutting force is periodic, from which the average machining power in the cutting zone at the steady state is derived. From the actual cutting force, the mechanical power is calculated. This calculation presented a good prediction, with a five percent error of the evolving mechanical power in comparison to experiments performed in the past for those terms.

In addition, for one of the machining models, after providing cutting performance parameters, we can obtain information about the actual cutting force and the cutting power in different cutting parameter conditions without building another machining model.

Keywords: End milling, cutting force, cutting power, finite element method (FEM)

THE EFFECT OF UPPER LIMB LOAD BEARING FEEDBACK SYSTEM ON WALKING STABILITY AND LIMB FUNCTIONING OF POST-STROKE PATIENTS

Orit Braun Benyamin

A stroke is one of the main causes impacting an individual's gait and balance. Hemiparesis is a neurological condition that affects nearly 80% of the 796,000 stroke survivors in the US every year. This lack of sensation, and therefore unreliable biological feedback, can cause a hemiplegic post-stroke patient to not push their walker with symmetric force while relearning to walk. Asymmetrically applied force directly impacts gait and stability, ultimately affecting safety and comfort.

The use of visual biofeedback/forceplate systems for the rehabilitation of patients with hemiplegia has been shown to improve stance symmetry in controlled experiments.

The purpose of this study is to compare outcomes (using the Berg Balance Scale, the Fugl Meyer Test, and the Timed "Up & Go" Test), following balance and mobility retraining by physical therapy, with and without the Handle Grip of a Walker feedback system.

This research is conducted with the physical and occupational therapy units at the Galilee Medical Center in Nahariya.

Keywords: Balance, functional mobility, hemiplegia, stroke, visual and auditory biofeedback

MOTOR FUNCTION IN ADHD

Orit Braun Benyamin

Attention deficit and hyperactivity disorder (ADHD) is a common syndrome affecting 3-20% of children and has become a significant public health problem. These studies aim to investigate posture stability by measuring center of pressure movements and their relation to dual tasks and cognitive load. The initial results show that students with ADHD have larger center of pressure movements compared with non-ADHD students. There is a striking elevation in the sway area of ADHD subjects when undergoing dual tasks and cognitive load.

Keywords: Attention deficit hyperactivity disorder, postural stability, single task, dual task

UPPER HAND TREMOR DURING A WRITING TASK – DEVELOPMENT OF A MEASUREMENT SYSTEM

Navit Roth and **Orit Braun Benyamin**

A major motor limitation that exists in humans is the phenomenon of tremor. Tremor may be the outcome of chronic or neurological diseases and pharmacological toxicological background. Tremor occurs mostly in the upper limbs, and the intensity (amplitude) and frequency level of tremor can vary throughout the day and may depend on stress level, amount of physiological effort of the relevant muscles, medication, movement characteristics, and orientation of the limb. Tremor assessment and diagnosis is carried out by the doctor through general neurological and general examination and does not involve quantified measurement systems. Development of an accurate, reliable measuring system, with a self-test capability, will enable doctors and people suffering from tremor to evaluate the effect and efficiency of treatment on tremor characteristics by means of quantitative parameters.

This research aims to define and build a tremor measuring system while performing a writing task. The system will include and compare measurements from accelerometers, motion capture analysis of relevant points through digital video analysis and coordinates of the pen pointer, and pen tilt and pen pressure measurements from a tablet system.

Keywords: Tremor, motion measurement, biomechanics

DEVELOPING DEVICES FOR PEOPLE WITH DISABILITIES: CHALLENGES AND GAINS OF PROJECT-BASED SERVICE LEARNING

Orna Muller, Vered Dangur, and Orit Braun Benyamin

Project-Based Service Learning (PBSL) is a hands-on pedagogical approach that involves the development of a product for the benefit of society. PBSL provides students with opportunities to design and develop innovative solutions for real clients with real needs. The study focuses on the perceptions of 13 mechanical engineering graduates who participated in a single-semester Rehabilitation Biomechanics course that includes development of tailor-made and low-cost assistive devices for people with special needs. The study aims to evaluate the long-term impact of PBSL on graduates after several years of employment in industry. The course is a part of an ORT Braude College of Engineering flagship project: "Engineers on Behalf of People with Disabilities".

Keywords: Project-based service learning, engineering education, people with disabilities, rehabilitation biomechanics

MULTI-OBJECTIVE NEURO-EVOLUTION

Adham Salih and Amiram Moshaiov (Tel Aviv University)

In recent years there has been an increase of interest in designing Neuro-Controllers (NCs) using multi-objective evolutionary computation techniques. Given the vast variety of multi-objective

evolutionary algorithms, selecting one for a specific problem is a non-trivial task. This research aims to provide a comprehensive comparison between two well-known evolutionary algorithms including NSGA-II and MO-CMA-ES, as applied to the evolution of NCs. The numerical investigation is based on two multi-objective navigation problems, in conjunction with two types of networks. In all the cases studied it was found that MO-CMA-ES is better than NSGA-II. The reason for the superiority is explored. First, it is shown that the competing convention problem cannot serve as an explanation of the observed phenomenon. A unique method is suggested for investigating the convergence of the networks. Based on the proposed methodology, it is found that for the cases studied, MO-CMA-ES has much better convergence properties. The differences between the two algorithms, and the uniqueness of the considered neuro-evolution problems, lead to the following hypothesis: It is postulated that MO-CMA-ES is superior as a result of its ability to fine-tune the solutions by changing particular genes, one at a time.

Keywords: Evolutionary neural-network, neuro-evolution, evolutionary robotics, multi-objective optimization

MANY-OBJECTIVE TOPOLOGY AND WEIGHT EVOLUTION OF ANNs

Adham Salih and Amiram Moshaiov (Tel Aviv University)

Neuro-Evolution (NE) combines the adaptation power of Artificial Neural Networks (ANNs) with the advantages of evolutionary computation to find networks capable of solving different tasks. The potential of NE has been successfully demonstrated in many studies involving application areas such as robotics, artificial life, computer games, and agent technologies. A major advantage of the evolutionary approach to ANNs is its ability to simultaneously search for both the optimal topology and weights. This type of NE is known as TWEANN (Topology and Weight Evolution of Artificial Neural Networks). This research aims at the development of efficient and reliable MO-TWEANN algorithms, as well as testing and comparing them in the context of robot navigation by way of neuro-controllers (NCs). The envisioned NCs for autonomous robots should cope with generalization and adaptation to changing environments. Specifically, in contrast to most of the existing MO-TWEANN algorithms that are restricted to a few objectives, we aim at algorithms that may handle a large number of objectives. This is expected to support the simultaneous evolution of NCs to many different environments, hence accelerating the evolution of generalized solutions.

Keywords: Evolutionary neural-network, neuro-evolution, evolutionary robotics, many objective optimization, TWEANN

MANY-OBJECTIVE TWEANN FOR SOLVING MULTI-CLASS CLASSIFICATION PROBLEM

Adham Salih and Amiram Moshaiov (Tel Aviv University)

This research deals with using many-objective topology and weight evolutionary artificial neural networks (TWEANN) algorithms for solving multi-class classification problems. The many-

objective (more than three objectives) feature opens up new possibilities for designing mixtures of class-experts (ensembles) for classifying many classes. In particular, the problem is defined as a many-objective problem in which each objective is associated with one class.

Keywords: Evolutionary neural-network, neuro-evolution, Pareto, many-objective optimization, multi-class, ensemble

TWO-PHASE FLOW; CREEPING FLOW ON SURFACES; ACCELERATED CHARGES; MANIFOLDS; FRICTION ANALYSIS

Ayelet Goldstein and **Ofer Eyal**

1. Multi-phase developed flow in a pipe: use of Green functions and other mathematical techniques for better understanding and simpler solutions for the physical situation; analogy with electric fields, currents, and potentials is investigated for modelling. Point singularities and their physical explanation, together with practical implications, are investigated.
2. Creeping flow on surfaces: use of complex analysis for finding pressure and velocity field when the flow is constrained to surfaces, with various topologies. Point sources and vorticity centers are studied as a cause for pressure gradients and velocity field.
3. Accelerated charges radiation: a new approach for the radiation emitted by relativistic accelerated charges.
4. Some of nature's laws are modified when space is regarded as a non-flat manifold: investigating the fundamental solution for essential operators. Application for multidimensional electrodynamics.
5. Friction: a) the puzzle of the modes of passage of a body from rest to movement; b) the motion of a body in the presence of friction, propelled by a rotating mass; and c) assisting the movement under friction by an internal movement.

Keywords: Two-phase laminar separated flow, potential problems on manifolds, accelerated relativistic charges, spheres, friction

ACTIVE ROBUST OPTIMIZATION

Shaul Salomon, Gideon Avigad (Vineland Research and Innovation Center, Canada)**, Robin Purshouse,** and **Peter Fleming** (University of Sheffield, UK)

This study presents a new framework for evaluation, comparison, and optimization of changeable products. Any product that can change its configuration during normal operation can be considered as a changeable product, making the framework widely applicable. By applying the methodology, designers can cope with uncertainties through adaptability rather than creating over-conservative designs. The framework is constructed around a new class of optimization problems – the *Active Robust Optimization Problem*. It is a nested optimization problem: the inner problem searches for the optimal configuration of a given candidate design at different scenarios of the uncertainties.

According to the distribution in performance with the optimal configurations, the outer problem searches for the robust set of features of the changeable product itself.

Keywords: Optimization, design for uncertainties, multi-criteria decision making, adaptive design

OPTIMIZATION OF A MULTI-ARM ROBOTIC FRUIT HARVESTER

Shaul Salomon, Gideon Avigad (Vineland Research and Innovation Center, Canada), and **Avi Kahani** (FFRobotics)

This study is part of the design process of a multi-arm robotic fruit harvester. FFRobotics is a start-up company that has developed a patented robotic arm for picking apples and other fruits. To use the technology on a commercial scale, a multi-arm robotic harvester that operates 12 arms simultaneously is being developed. The optimization study includes algorithms for coordination between the arms to minimize interference and maximize yield, and finding the optimal design parameters of the harvester itself, such as number of arms, dimensions, and component selection.

Keywords: Optimization, design for uncertainties, robotics, smart agriculture

LOCOMOTION OF A SKATING ROBOT

Shaul Salomon and Avi Weiss

Skating is a unique form of locomotion that enables fast and energy efficient movement on slippery surfaces such as ice. High efficiency can also be achieved on non-slippery flat surfaces using roller skates. This research studies the kinematics and dynamics of the skating motion to design an autonomous robot that can efficiently progress on ice and other flat surfaces.

Keywords: Kinematics, dynamics, control, mobile robots

SOOT VOLUME FRACTION MEASUREMENT USING A DIGITAL CAMERA

Victor Chernov

Soot is a particulate combustion product consisting of aggregates of small carbon spheres. The spheres are usually tens of nanometers in diameter. The aggregate size can vary between a few and several dozen spheres. In most cases, the volume fractions are of an order of magnitude from a single to tens of ppm. Soot is an unwanted product of many combustion systems and poses a major threat to health and the environment. However, it is not an inherent product of combustion, and it is possible to have combustion without it.

One of the challenges in soot research is fast, reliable measurement of soot volume fractions. Low volume fractions and hostile environments make the task non-trivial. The measurement process is long, sensitive to various parameters, and cumbersome. This research develops an experimental system for soot volume fraction and temperature measurement in laminar flames. The system

is based on the Spectral Soot Emission (SSE) measurement system for laminar diffusion flames. It is assumed that in a sooting flame, the radiance in the visible range can be attributed to soot. By measuring it at different wavelengths, temperature and soot volume fractions can be found. This research attempts to improve the system using high-resolution, high-speed cameras, and advanced image processing techniques to characterize diffusion flames. These improvements can reduce the sampling time of a single flame from one day's work to less than an hour. A larger number of points can be sampled for each flame, enabling better flame analysis.

Keywords: Diffusion flame, soot, combustion

ELECTROMECHANICAL BUCKLING AND NUMERICAL MODELING OF MULTI-PHYSICS PHENOMENON

Samy Abu-Salih

Modeling of micro electromechanical systems (MEMS) is a pivotal step in achieving maximum efficient design and high accuracy of micro systems (MEMS devices). The research focuses on:

- Electromechanical buckling of micro structures with application to MEMS devices
- Modeling the chemo-electro-mechanical response of micro hydrogel structures
- Modeling the electromechanical response of micro piezoelectric sensors and actuators
- Modeling the mechanics of cavitation

Keywords: Modeling of micro systems, MEMS, electromechanical buckling (EMB), cavity expansion in solids

MODELING OF CHEMICAL NITRIFICATION PROCESSES IN ANAMOX

Samy Abu-Salih, Essam Sabah, Carlos G. Dosoretz (Faculty of Civil and Environmental Engineering, Technion–Israel Institute of Technology**), and Ali Nejidat (Institute for Desert Research, Ben-Gurion University)**

- Modeling of chemical nitrification processes in ANAMOX bacteria

Keywords: Nitrification process

DEVELOPING CONSTITUTIVE MODEL FOR PLASTIC MATERIALS WITH APPLICATION TO METAL CUTTING PROCESSES

Samy Abu-Salih and Rami Masri

The focus:

- Developing a new explicit constitutive model for plastic material response
- Finite Element Analysis (FEA) of metal cutting and chip generation
- Finite element modeling of cavity expansion in solids

Keywords: Metal cutting, chip generation, finite element analysis, constitutive model of plastic materials

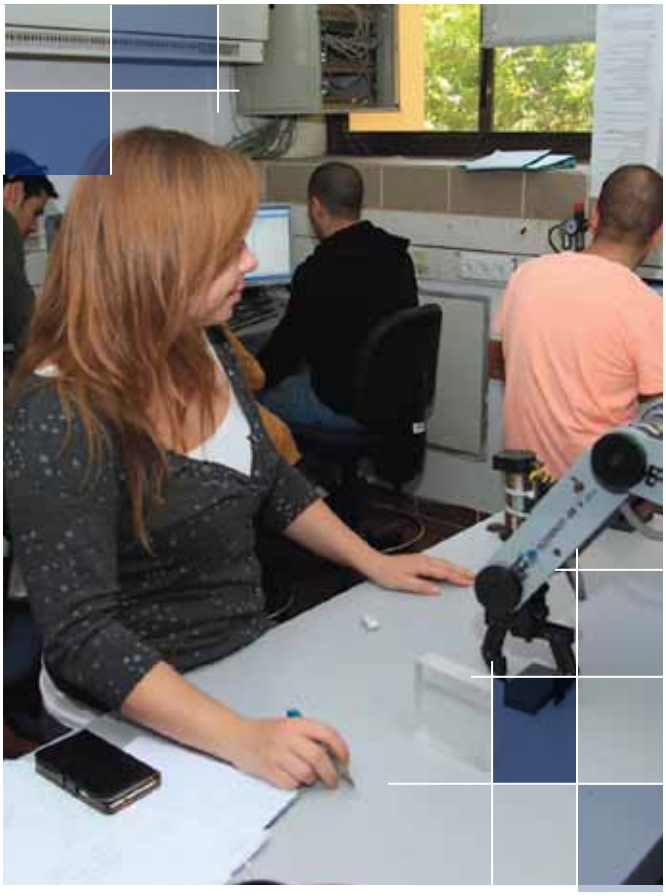
MECHANICS OF CAVITATION, PENETRATION, PERFORATION, AND SHIELDING

Rami Masri

The research focus:

- Investigating the mechanics of deep penetration and ductile plate perforation of protective targets by rigid projectiles
- Investigating the mechanics of hole growth (cavity expansion) in protective plates under different conditions
- Investigating the mechanics of quasi-static and dynamic cavitation phenomena in different solids
- Investigating the mechanics of hole growth in hyperelastic materials (biological tissues)

Keywords: Cavity expansion, cavitation in solids, ductile hole growth, deep penetration, plate perforation, ballistic limit, specific cavitation energy, biological tissues



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