Table of Content

Mass-customization in the Field of Assistive Technology

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Development of an autonomous anatomic seating system, Customized to the clinical and functional needs of users.

Assistive Technologies are specialized products aiming to partly compensate for the loss of autonomy experienced by disabled people. Earlier studies suggested that proper seated position is the main goal to normalize the muscular tone, improving the optimal function. Additionally, proposed that adaptive equipment which is provided to CP children should be customized individually according to the child's functional and contextual needs.

Mass-production assistive technologies, usually designed, general and adjustable, to fit the large market as possible. As a result, off-the-shelf products are too general and do not fit individual needs. Custom-made products fit precisely the needs of the individual, by being designed accurately for the body measures and personal needs. There is a fundamental need for custom products, whether for luxury fields such as sports, military, or space, where optimal performance is essential. But moreover for the disabilities field, where custom solutions are critical to assist in activities of daily living (ADL) and rehabilitation. However, custom-made products are expensive and not achievable in most cases. At the same time, craftsmen who make the custom solutions are disappearing, and with them, the professional knowledge.

We are developing and designing a parametric anatomic seating system, based on clinical and craftsman praxis, providing a fully customizable product, adapted for digital-manufacturing tools (laser cutting, CNC milling, 3D printing). In this way, we can produce every product unique for every individual function and need. Additionally, we preserve craftsman knowledge, serving people with disabilities. Our goal is to develop products that enable the clinical staff as a physiotherapist, occupational therapist, etc., to create anatomic solutions at the push of a button — reducing the time between the measuring and the final product.

The lecture focuses on the possibilities of digital manufacturing technology in the assistive-technologies field, looking into the gaps and the challenges, also talking about the transaction between rapid prototyping to the real product, using large-scale additive manufacturing (FGF) technology.

https://www.testa-seat.com/
Mass-customization in the field of assistive technology




The Design, Development, and Optimization of the Structural Form of 3D Printed Open Sea Macroalgae Intense Aeration Cultivation Pod

Yuval Gur

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It is generally accepted that the areas of marine environment and agriculture are facing a variety of challenges. The most consequential are biodiversity reduction, change in nutrients balance in the sea, shortage of valuable land, and worldwide increasing need of protein resources for humans. There is now much evidence that open-sea algae cultivation may have a significant potential in facing those challenges.

By using the natural function of algae in the marine ecosystem, a positive effect could be achieved. While the algae do photosynthesis, it absorbs carbon dioxide and release oxygen. Furthermore, it absorbs nitrogen and phosphorus at high rates and contains a high ratio of protein. There has been an ongoing effort to foster farming and mariculture to offshore cultivation for more than two decades.

Although these efforts, offshore algae cultivation methods and equipment have developed slowly due to outdated technology and equipment that is not designed for aquaculture. Using design research discipline and additive manufacturing as a key approach, can significantly innovate this research field .

The research presents a process of design, development, and optimization of open-sea algae cultivation methods using bridge-based 3D printing method combined with algorithmic design. The research goal is to compare various forms and function factors; to improve the design system for growing algae in a marine agriculture environment.

Professor Ezri Tarazi- Main Advisor
Professor Nitai Drimer- Associate Advisor
Doctor Alvaro Israel- Consultant
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Bio-inspired ceramic 3D printed artificial reef

Ofer Berman[1], Michael Weizman[2], Asa Oren[3], Haim Parnas[1], Nadav Shashar[3], Ezri Tarazi[1]

This research focuses on examining the possibilities 3DP has on designing highly complex marine habitats made from natural and neutral materials, targeting the phenomenon of coral reef degradation. This structural and biological decay man be partially restored by creating artificial reefs (ARs). Today, most ARs are created through conventional industrial processes using large-scale manufacturing methods, such as mass-produced concrete casts. The most recent innovation in the field has seen the use of additive 3D printing to better satisfy the need for a reef that provides high morphological complexity in a marine environment. While demonstrating high levels of complexity and variety, these methods require long production time per unit as compared to conventional fabrication. Hence, these methods need greater scale production abilities, while maintaining the desired complexity features. Our approach directly controls the movement of the printer, designing its choreography while extruding the material. In the current research, a new method is being explored for creating ARs in the field of active marine restoration using design methods. What guides the design of the new ARs is the functional aesthetics of natural corals, translated into the machine language. The focus of the research has been on the creation of (a) tabular and (b) ceramic structures. The tabular structure was chosen before the two alternative coral variations (branching and massive) due to his ecosystem function importance. The clay and afterward ceramic was chosen as the working material for four main reasons: (a) high structural abilities, (b) porosity levels, (c) affordability, and with (d) long track in biological settlement research. To better understand the behavior of the created AR and the deployment process, a custom-made AR was deployed in the Gulf of Eilat/Aqaba (GoE/A), at the northern tip of the Red Sea.

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Matter of Perspective – A Collaborative Course Between Computer Science and Architecture

Yoav Sterman[1], Miri Ben-Chen[2]

“Matter of Perspective” is a first-of-its-kind collaborative course between CS (Computer Science) and Arch (Architecture) departments. The course is taught by Yoav Sterman from Arch, and Prof. Miri Ben Chen, and Prof. Gershon Elber from CS. In this course, students work in mixed groups on joint projects with the aim to creatively apply geometric algorithms and fabricate physical objects using additive manufacturing and other computational fabrication methods. The goal is to expose CS and Arch students to each other’s worlds and spark synergetic collaborations. A pilot version of the course was given successfully in the Spring ‘21 semester. Some project examples are a voxelization system, 3D dithering, and shape-shifting auxetic patterns. For this talk, we will share our experiences from teaching this unique course, share projects that were done by the students, and discuss the challenges and opportunities for future courses.

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Shell-lattice construction based on regular and semi-regular tiling via functional composition

Sumita Dahiya[1], Avi Shein[2] and Gershon Elber[3]

This manuscript outlines a methodology and algorithm for the design process of shell-lattice structures based on the dual regular and semi-regular shapes. It introduces a 2-manifold, parametric freeform shell type of tiling to tessellate the domain of any given bivariate deformation map. The tessellated domain is functionally composed into the deformation map to obtain freeform shell-lattice structures in 3-space. Given any primal regular or semi-regular pattern, the intrinsic control over the design parameters of the thickened dual graph, results into a variety of tilings that differs in both aesthetic appearance and final manifestation. The article concludes with several results from the implementation of the algorithms, including 3D printed parts.

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Conformal Microstructure Synthesis in Trimmed Trivariate based V-reps

Q Youn Hong and Gershon Elber

Faculty of Computer Science, Technion

Recently, a method to construct heterogenous and porous microstructures has been developed through tiling microstructures in Volumetric representation (V-rep) based macro shape models. This tiling method reduces the complexity of designing microstructures by separating the design of microstructure from the macro shape, but assumes that the macro shape must be a form of trivariate tensor-product deformation map.

In this talk, we present a microstructure tiling scheme for V-rep models consisting of trimmed trivariates. Trimmed trivariates are formed by hierarchically applying Boolean operations to full tensor-product trivariates. An existing tiling method is employed to tile individual primitive tensor product trivariates in a conformal way, only to handle the intersection of the microstructure tiles with the trimming surfaces of the trivariates. One-to-one and two-to-one bridging tiles are then constructed along the trimmed zones, while tile-clipping is completely avoided. We consider Boolean operation cases of subtraction, intersection and union. The result is a set of, regular in the interior, possibly heterogeneous, trivariates, that defines the whole microstructure arrangement. This result is fully compatible with iso-geometric analysis as well as heterogeneous additive manufacturing. Examples are presented, including of 3D printed heterogeneous microstructures.

Teacher education for collaborative cloud-based design and 3D printing with Onshape

Dan Cuperman[1], Igor Verner[1], Laura Levin[1], Moshe Greenholts[1], and Uzi Rosen[2]

This study proposes to enhance engineering design education in schools by integrating online collaborative project-based activities that foster the learning of new disruptive technologies and the development of skills needed in the modern world. We developed a pilot course on methods of teaching engineering mechanics that included training in 3D design and printing using the cloud-based platform Onshape. The assignment was to design a web-controlled walking robot and make its mechanism through print-in-place fabrication. In the study, we examined how participants of the course learned collaborative design with Onshape and how they used analytical thinking to create design solutions. The research tools included questionaries, written commentaries, and data analytics with the learning management system Onshape Education Enterprise (OEE). Based on the commentaries of course participants, we identified several characteristics of learning collaborative design, while OEE documented participants' engagement in the design projects. Responses to the questionnaires indicated that the cloud-based learning environment and the collaborative design assignment prompted the participants to analytically elaborate their designs.

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Advantages and Challenges of Incessantly Printed Engine

Michael Palman[1] , Yohai Abraham[2] , Vladimir Popov[3] , Beni Cukurel[4]

Modern small scale UAVs are commonly powered by micro-gas turbines. These micro jet engines have thrust rating below 1 kN and have disproportionate cost that varies between 30,000 to 150,000 USD. Moreover, significant efforts are invested towards prolonging the service life of these small yet expensive engines, and maintenance becomes an important subject, which involves long chain of suppliers and overall work expenditures that have the potential to even surpass the base price of the engine.

Extremely cheap limited-life micro-jet engines have the potential to eliminate supply chains, warehousing of replacement parts, maintenance procedures, and all expenses associated with it. However, despite the relatively simple design of a conventional micro-turbojet engine, its manufacturing involves long and costly processes due to presence of numerous parts, different manufacturing methods, logistics of various subcontractors and collaboration of different departments that assemble and qualify the product. Instead of relying on this conventional process, the proposed concept entails development of a non-conventional engine design that can be additively manufactured in its final topology through a single uninterrupted print that encompasses both the rotating and stationary components. Requiring only a metal printer and an operator, the cost of the engine will be diminished to capital equipment depreciation and raw material, with an expected cost reduced merely to a small fraction of the current engine market prices. Such engine will include only two major parts - static casing with embedded combustion chamber and a rotating shell structure. This rotating part will include compressor and turbine impellers connected by a thick hollow shaft that will enhance the rotordynamic performance. The hollow shaft connecting the compressor and the turbine will also serve as a fuel driven hydrostatic bearing. The fuel will subsequently evacuate through perforated media towards compressor-diffuser region and mix as an aerosol with incoming air flow. In a pursuit to reduce engine size, porous media combustor will be used to burn the premixed fuel-air mixture. The rotating component of the engine is designed to be balanced after the manufacturing process only through external ad hoc removal of mass from the surfaces.

Discussed concept has number of challenges associated with turbomachinery and bearing design that need to be addressed while considering the limitations of the state-of-the-art 3D manufacturing processes.

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Shape maintenance of 3D-bioprinted hydrogel constructs using alginate support

Abigail Newman Frisch, Shlomit Edri, Idit Goldfracht, Majd Machour, Shulamit Levenberg

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3D printing is a flourishing technology in the field of tissue engineering. Materials are deposited in successive layers to fabricate complex 3D structures that may be used for development and disease modelling, drug testing and implantation amongst other tissue engineering applications. 3D printing is used both to print scaffolds that support and promote cell growth and to print cells directly in a process known as 3D bioprinting. In this process, cell-laden biomaterials are deposited in a spatially defined manner to achieve specific architectures that are pertinent to their biological utilization. Thus, 3D bioprinting allows for investigating and controlling cellular interactions. Cell spreading throughout the printed construct may cause deformation and shrinkage of the printed hydrogel, which could in turn influence cellular behaviour. This work investigated using an alginate support layer to maintain the shape of the printed construct. We showed that incorporating alginate support achieved shape maintenance of complex structures, whilst also allowing cell spreading and proliferation throughout the printed construct. This method may be applied to 3D bioprinting of various cell types where shape and position are critical for mimicking the native tissue and important to its function.

Long-term stabilized amorphous calcium carbonate as an ink for bio-inspired 3D printing

Hadar Shaked, Iryna Polishchuk, Alina Nagel, Yehonadav Bekenstein, Boaz Pokroy

Faculty of Materials Science and Engineering and RBNI, Technion

Biominerals formed by organisms often possess complex morphologies and superior mechanical properties despite their single-crystalline nature and their formation under ambient conditions. A good example for such biomineral, formed by the course of biomineralization, is calcium carbonate (CaCO3). CaCO3 is a biomineral commonly used by various organisms to form skeletons, protective shells, teeth, clamps, and optical mediums. The enhanced characteristics of biogenic CaCO3 are achieved due to crystallization through an amorphous, unstable precursor, amorphous calcium carbonate (ACC).

In this work, inspired by organisms' amorphous-to-crystalline route for enhanced CaCO3, we used robocasting, a common additive manufacturing technique, to 3D print long-term Mg-stabilized ACC under ambient conditions with high solid-loadings and on-demand crystallization. We tested three non-hydrated organic binders; glycerol (GLY), ethylene glycol (EG) and triethylene glycol (TEG), and examined their affect on the stabilization and crystallization route of ACC. We found that GLY, a highly hygroscopic compound, promotes slow crystallization endorsed by heat, allowing the growth of calcite crystals while using ACC as a reservoir. GLY has also exhibited larger grain size and higher Mg content in comparison to EG and TEG. Both EG and TEG exhibited long-term stabilization of ACC with minor crystallization in un-favorable directions of calcite and aragonite. Moreover, EG and TEG demonstrated the ability to perform on-demand crystallization by exposure to humid condition. We believe that utilizing this bio-inspired method may pave the way for a new bio-inspired route to low-temperature 3D printing of ceramic materials for a multitude of applications.

Counteracting cellular traction forces in 3D bioprinted hydrogel scaffolds

Majd Machour[1], Noy Hen[2], Idit Goldfracht[1], Havazelet Bianco-Peled[2], Shulamit Levenberg[1]

3D bioprinting is an emergent promising technique for tissue engineering, in which cells suspended a pre-crosslinked hydrogel (termed bioink) are extruded in a layer-by-layer manner in specified patterns generated from patient-specific non-invasive imaging. 3D bioprinting enables high resolution control over bioink deposition as compared with other traditional tissue engineering methods. Several techniques and bioinks have been developed for 3D bioprinting, which can be crosslinked using a variety of methods such as photo crosslinking, enzymatic crosslinking, ionic crosslinking and physical crosslinking. To enhance the printing resolution and expand the library of available bioinks, the use of support baths has been suggested. Support baths are shear thinning materials that behave as a liquid when the printing nozzle moves inside it, while acting a solid to support the extruded filament.

However, an often-overlooked drawback of 3D bioprinting is the contractility of the cells, which can lead to dramatic shrinkage and deformation of the printed construct after a short incubation period, which in turns prevents the construct from suiting the defect's dimensions. In addition, the contraction leads to unexpected changes to the hydrogel network density and cell density.

Herein we propose a method for the prevention of hydrogel contraction, while enabling high-resolution bioprinting of a wide variety of bioinks and providing a compatible growth environment that enhances cell viability and function. Our method allows for the fabrication of patient-specific geometries that can maintain their structural fidelity and cellular viability after long-term incubation.

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Muscle cells maturation on edible, 3D-printable non-animal derived scaffolds, for cultured meat development

Iris Ianovici, Idan Redensky, Yedidya Zagury , Neta Lavon, Shulamit Levenberg

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Cultured meat is a promising candidate to cope with the rising meat products demands over the past decades, known to cause environmental, health and ethical problems. For this purpose, novel tissue engineering techniques are harnessed to create an edible muscle tissue, made from suitable biomaterials and cell types. The scaffolding materials must meet key requirements to enable cell growth and maturation, and will preferably contain nutritional values themselves. For cultured meat, it would also be preferable to design a repetitive, customizable fabrication technology, for enabling a scale-up production in the future. One promising method for such fabrication is 3D bio-printing, with printers suitable for precise 3D deposition of cells and 'bio-inks' - materials naturally found in/mimicking the cell environment - in highly customizable, complex structures. Previous works have reported successful printing of engineered tissues, including skeletal muscle. Yet, research relating to 3D printing for cultured meat purposes is still in an infancy stage, as it demands non-animal derived, printable and potentially edible scaffolding materials.

Herein we propose nutritious scaffolding compositions which enable a flexible fabrication process of an edible bovine muscle tissue. The biomaterials were assessed both for 3D-printing capabilities and their support of growth & maturation of isolated Bovine Satellite Cells (BSCs) into muscle-fibers. 3D-printing of scaffolds in a multitude of geometries was successful, as well as BSCs attachment & spreading on these biomaterials. Maturation of the cells was later found to be successful, as the presence of myotubes was observed. Cellular printing was also enabled by this gentle fabrication process, exhibiting recovery of the deposited cells overtime. Thus, the suggested 3D-printable compositions enable a customizable, cell-friendly fabrication of nutritious scaffolds in well defined geometries, capable of supporting BSCs growth and maturation, as a step towards an edible engineered muscle tissue.

Development of 3D printed grafts based on bone extracellular matrix (ECM) for bone regeneration

Rotem Hayam and Marcelle Machluf

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Bone is a dynamic tissue with the ability to heal and repair without scaring. Nevertheless, in cases of delayed recovery or large non-healing bone defects resulting from trauma, tumor, or infection, bone grafting is required1. The extracellular matrix (ECM) naturally provides cells with a supportive framework of structural as well as functional proteins, carbohydrates, and signaling molecules2. Furthermore, the ECM was proved to have an important role in successful bone healing, as it increases the interactions among osteoprogenitor cells and growth factors.

The overall goal of the proposed research was, therefore, to reveal the potential of bone ECM (bECM) as a bioactive material for the bioengineering of advanced bone grafts. To this end, ECM was isolated from porcine and human bones, and their distinctive properties were studied, revealing high similarities between the human and the porcine bECM, and indicating the high potential of porcine bECM for bone grafting. Furthermore, in vitro and in vivo biocompatibility studies showed no indication for an immunological response.

To address the technological aspects of graft additive manufacturing, we first developed a reproducible ECM bio-ink that can be thermally gelled and further crosslinked using natural crosslinkers. Next, we investigated the technological feasibility of 3D-bioprinting complex pbECM scaffolds by addressing the effect of different biomaterial properties and system parameters on the process and its outcomes. In addition, we studied the incorporation of osteogenic factors such as BMP-2 in the scaffolds for the enhancement of clinical efficacy and osteogenic properties.

To conclude, we have established the scientific as well as the technological basis for the development of novel 3D-printed pbECM-bone grafts and demonstrated their great potential use for bone regeneration.

Laser Cooking and Food Printing

Hod Lipson

Columbia University

New modalities and facilities by Metal Additive Manufacturing Center

Vladimir Popov

Israel Institute of Metals, Technion

Metal Additive Manufacturing Center (MAMC) works on the development and characterization of new and existing metals and alloys. The research uses Powder Bed Fusion machines for Selective Laser Melting (SLM) and Electron Beam Melting (EBM).

We will present our current activities in aerospace, medical, and advanced materials applications. For the last application, we have developed a customized system for small amounts of powders. Even mixed powders could be manufactured by this approach performing in-situ alloying.

We will present the gas atomizer and first experimental findings in gas atomization powders production for the development of new metal alloys for additive manufacturing and powder metallurgy.

Among the newest facilities of the MAMC, the nondestructive testing (NDT) system by VibrantNDT will be shown and explained. The revolutionary Process Compensated Resonance Testing (PCRT) measures resonance frequencies through whole parts, allowing customers to test every part and significantly increase final product quality by detecting process variation and structural defects.

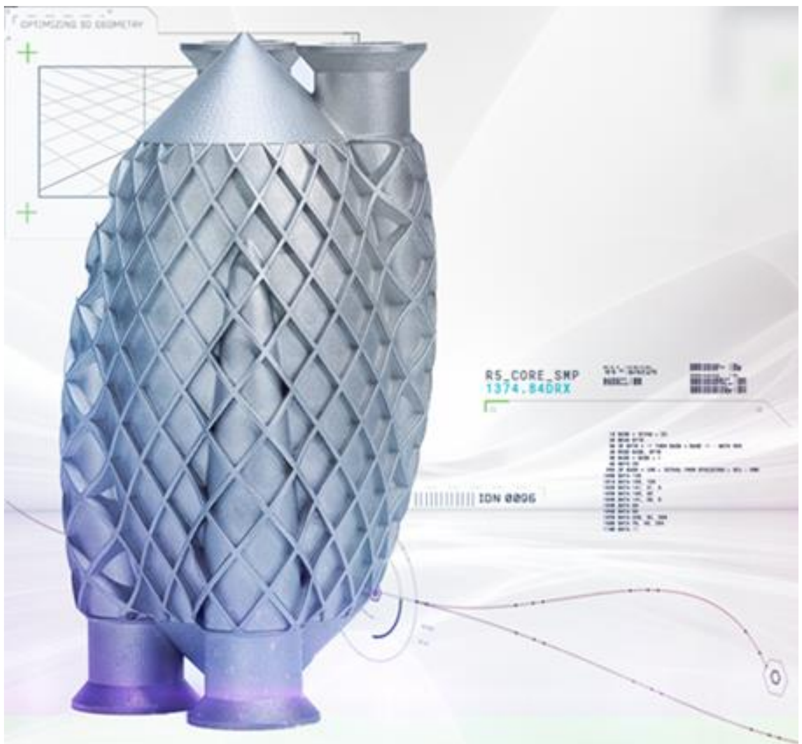
Inspired Engineering: A revolutionary Heat Exchanger with Additive Manufacturing

Jose Coronado

Director, PTC Product Management

In this session we will review the end-to-end digital workflow to design and produce a truly innovative heat exchanger, using self-supporting gyroid lattices. The result being a one piece heat exchanger printed with no supports to be removed. Up to 4 times up in thermal efficiency and half the size.

A. Vlahinos (Advanced Engineering Solutions LLC, USA); J. Coronado (PTC, CAN); D. Rakestraw (PTC, USA); D. Krzeminski (EOS North America USA); F. Alefel (EOS, DEU)



Bio: Mr. Coronado is the Creo Product Management Director for Creo Manufacturing applications. He oversees the direction of Manufacturing Solutions within Creo, including Additive Manufacturing, Machining and Mold/Cast design, among others. Mr. Coronado has been working on the Manufacturing Industry for more than 30 years, with experience ranging from being a CAD/CAM user in a High-Tech Mold-Making facility, to multiple Technical, Sales, Business Process Consulting and Product Management roles at IBM and PTC.

Mr. Coronado earned a degree in Mechanical and Electrical Engineering, and an MBA.

Stratasys newly introduced polymer portfolio with focus on Materials and R&D solutions

Ronny Eden

3D Printing Department CTO, Su-Pad

Freshly updated portfolio that covers the arena of professional polymers printing solution. We will describe the comprehensive AM technologies toolbox with focus on material development kits and R&D software packages to enable design to manufacturing on a voxel level with unique printing interventions possibilities.