Finalists

purmundus challenge 2021

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HEXR I EOS I Arkema I Prototal I Jamie Cook I Henry Neilson I Theo Clarkes I Mark Brown I Jess Lewis I George Jary

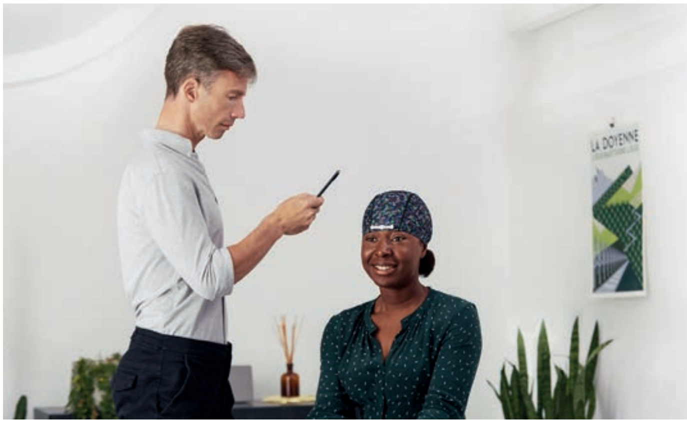
HEXR, the world's first custom fit cycle helmet

Description

HEXR, the custom fit cycle helmet. Our unique design uses a honeycomb structure to offer market-leading head protection while ensuring maximum comfort.

The creation of the helmet starts with a fitting-scan of the head, which is quickly measured by the our guided app using a cloud of points and the custom fitting HEXR is automatically generated on the server.

HEXR places great emphasis on social impact and sustainability - the PA11-based material consists of 100% castor oil. It is sustainably sourced by Arkema through the Pragati initiative, which supports sustainable farming methods, reduced water consumption and fair working conditions. The inner honeycomb structures and the smaller helmet components are 3D printed. The finishing touches include the assembly outer shell, chin straps, padding and an optional 3D printed ratchet system. The helmet is not only custom made, but additionally personalised with the customers own engraving to truly give the helmet that personal touch. HEXR is one of the first products to make it to mass production on the market through hybrid manufacturing using Advanced Technologies. The helmet also provides groundbreaking safety standards without compromising fit or aesthetics.



Urwahn Engineering GmbH I Sebastian Meinecke I Silke Walter

Waldwiesel.E - The Gravel E-Bike

The Gravel E-Bike

With our Waldwiesel.E, we have developed the first gravel e-bike that we mass produce using metallurgical 3D printing according to the principle of lean manufacturing. In designing our Waldwiesel.E, we pushed metallurgical 3D printing to the limits of feasibility to create a balance of form, function, lightweight construction and material.

The use of 3D printing allowed us to develop a steel frame design never seen before. The special rear end suspends the rear wheel elastically and generates a new kind of riding comfort, as any bumps and irregularities can be compensated for. Accompanied by the targeted optimization of the 3D printed components, the system weight could also be drastically reduced.

In terms of looks, the steel frame of the Waldwiesel is unparalleled and is more reminiscent of high-end monocoque frames. If you follow the elegant profiles in detail, you can also discover numerous technical integrations, such as a GPS tracker, LED light units and a powerful electric drive. This makes hunting through the forest a visual and functional pleasure.

Functionality

The precise electric drive adapts to the rider's riding style and puts a big smile on the face thanks to a powerful 40 Nm of torque at the rear wheel. The battery with a range of up to 80 km is discreetly integrated into the down tube. The Waldwiesel.E is navigated digitally via an app in keeping with the times, while emerging dangers are brought directly into view via the bright LED headlights.

Design

In designing the Urwahn Gravel e-bike, we were keen to take the Waldwiesel.E to a new level by merging novel technologies with thoughtful design and breaking with tried-and-true structures. Essential for the reinterpretation of the frame structure was the demand for a balanced relationship between form and function, resulting in an aesthetic and user-friendly overall appearance.

Material choice

With our steel frame, we revolutionized frame construction using 3D printing. Our unique build structure rivals conventional aluminum frames in weight and even takes its cue from the look of modern carbon frames.

Quality of workmanship

We have regionalized our production and work only with selected industrial and cooperative partners who, like us, are committed to quality products and novel manufacturing techniques.

Sustainability

By anchoring our production regionally, we create a profound transparency characterized by a fair wage policy and adequate labor relations towards all actors involved in the development and production.

Druckwerk I Valena Ammon

Weaving Porcelain

Description

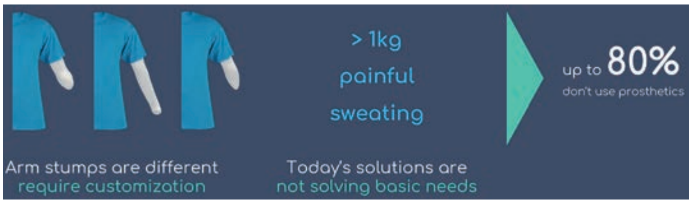
The woven-like mugs from Druckwerk have a texture that invites you to touch them. The white porcelain is only glazed on the inside to show off the texture more on the outside. The process of 3D printing creates a seam on one side of the mug that further enhances the impression of textile textures. Each mug is unique and may have small irregularities in the woven texture.

macu4 I Dr. Myriam Lingg I Lukas Schiller I Alec Chevrot

macu4 forearm prosthetics

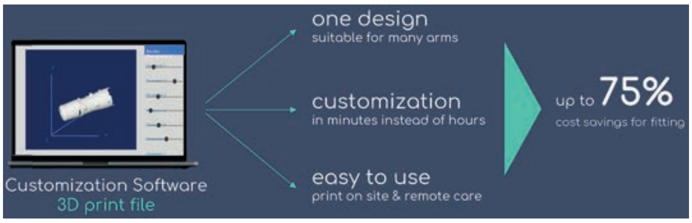
Opportunity

Customization is not cost-effective + offerings are uncomfortable & little lifestyle supporting



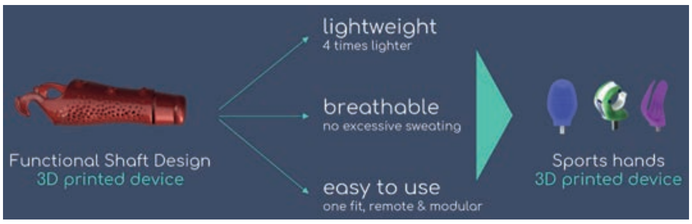
Part 1 of solution

The input parameters can be derived from a scan or a manual measurement



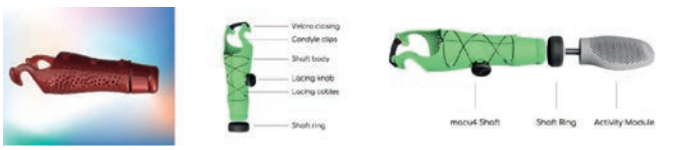
Part 2 of solution

The macu4 shaft design is modular and can be used for example with our sports hands



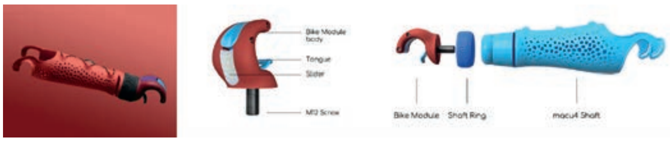
Design – The Shaft

It is customizable for many arms, is lightweight, breathable and intuitive in using it.



Design – The Bike Module

It gives you support on a handlebar, whether it's a bike, scooter, lawn mower or shopping cart. It allows to steer while guaranteeing an ergonomic posture



Design – The Ball Module

It supports you in certain ball sports - pick up a ball from the ground, hold it and throw a ball. It works for balls from the size of a table tennis ball to tennis balls.

Design – The Swim Module

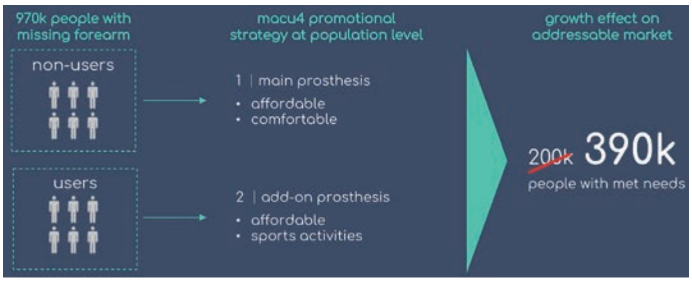
It makes it easier for you to displace water with your arm and benefit you in various swimming styles. For example, freestyle, backstroke or breaststroke.

Usability

macu4 is currently tested by 20 users which provide important insights

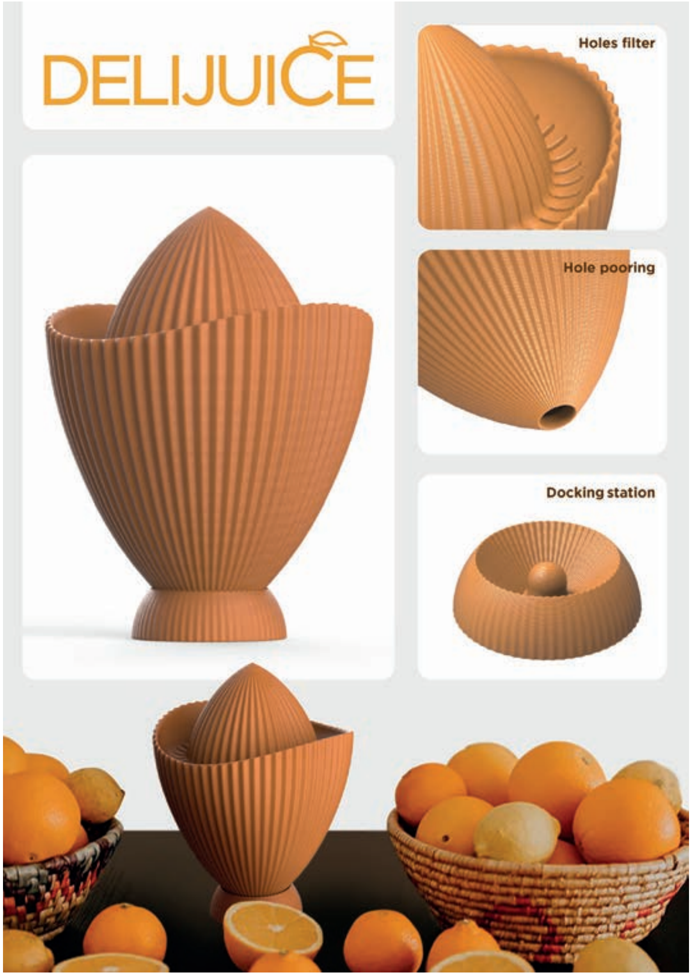
Market

USD 1.5B and 20M people worldwide (upper & lower limbs)



Roberto Trunfio

Delijuice



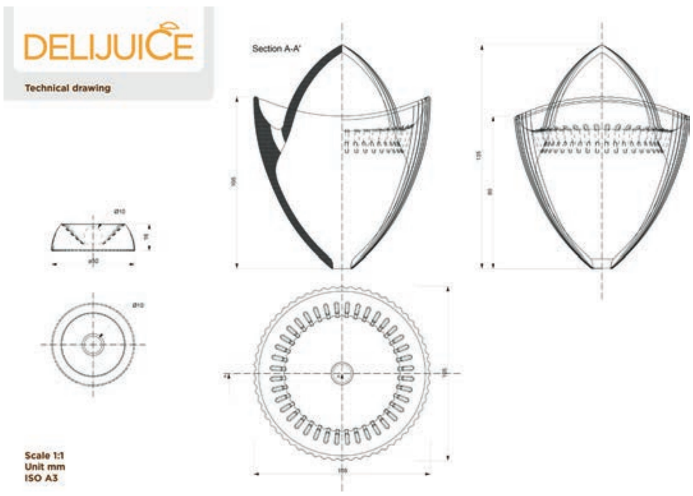
3D printed Juicer

The Delijuice Juicer was born from the idea of wanting to give a new life to food waste. Various sectors of the food supply chain have been analyzed and their problems, opportunities, studies carried out and already active projects have been evaluated.

The citrus sector was selected as the best for its potential and the ability to act and create something starting from waste, using 3D printing technology.

The project is a juicer made with citrus waste processed and processed into filaments for 3D printing. It could be the first in a family of similar products.

Delijuice project wants to enter the supply chain, creating new connections hoping to communicate and promote attention to food waste. The circular economy model of delijuice starts from the waste from the 4 main phases of the supply chain and promises to give back products designed not only for the final consumption phase but will also undertake to design products useful for collection, transport and sales packaging. It will also go live by creating real user experiences in the field and in the laboratories.



Citrus colors palette

The color palette is inspired by the world of citrus from the light and dark green typical of the leaves and lime, to the shades of yellow, orange, pink, lemon red, orange, grapefruit, blood orange to the classic black and white.

Glaze Prosthetics I Sylwia Kruźlak

Symbious active hand

Symbious is a brand new solution for prosthetics

Sleek design combined with enterprise technology - Multi Jet Fusion results in a coherent product that not only incorporates a completely new approach to Terminal Devices but exceeds the most sophisticated dreams of upper limb amputees.

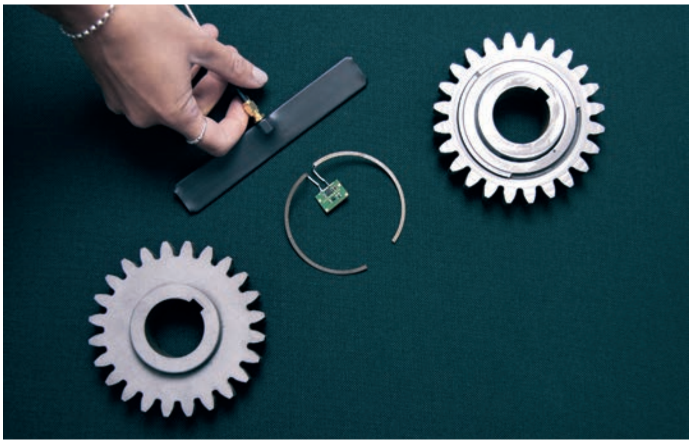
Key features:

- organic shape
- wide range of colors
- adaptive size regardless the age of the patient
- durable and lightweight
- wrist rotation with locking positions
- interchangeable skins
- reinforced vulnerable areas
- grip enhancements

In addition to common design principles that were followed throughout the design phase it is worth mentioning that some of the Design for Additive Manufacturing and Design for Assembly rules were accommodated.

Fraunhofer IGCV I Veronika Stapff I Maximilian Binder

Smart Gear



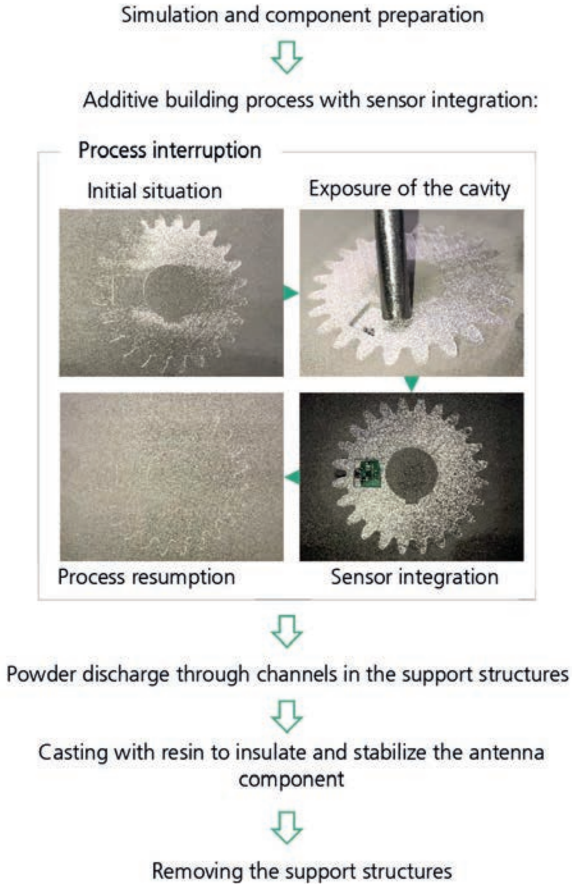
Smart Gear with integrated RFID accelerometer

The Smart Gear is able to generate sensor data inside without batteries (passively, without additional energy supply) and send it wirelessly via the RFID-frequency UHF (868 MHz) to an external receiver. The data can be recorded by means of a reader at a distance of approx. 10 mm. Measured values are relevant for examining gearwheel / gearbox faults and for observing gearwheel behavior. The integration of RFID-sensor technology solves challenges in the integration of electronics in the component, such as data transmission from a rotating component. Additive Manufacturing (AM) makes it possible to integrate and use passive sensor technology inside the gear. In order to transmit signals in the required energy range despite the impermeability of case-hardened steel to frequency bands, an antenna was designed out of the same material (20MnCr5) and optimized in its geometry dependent transmission and receiving properties. The Antenna is additively manufactured together with the gear, is electrically isolated on the front side of the gear and is conductively connected to the sensor system inside the gear. By designing a curved antenna shape, the data from the eccentrically rotating sensor system can be acquired with a statically positioned reader. To ensure that the manufacturing process can be carried out within a single building process, support structures are built from solid material. The cavities are then filled with insulating material thus the antenna and the sensor system are mounted in a fixed position and the support structures can be removed.

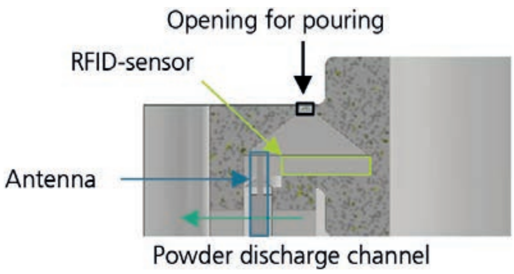
Conclusion

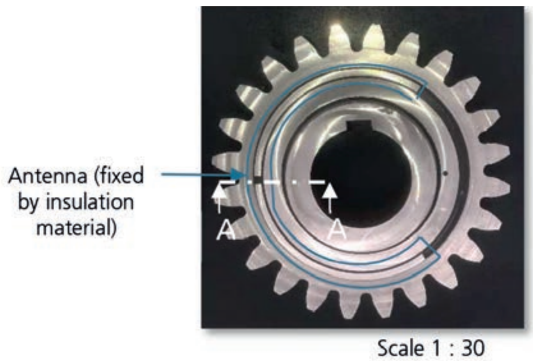
The Smart Gear is a multifunctional component with an additional passive, battery-free sensor system and additively printed RFID antenna. The mechanical benefit of the power transmission of a gear is supplemented by sensor technology and a structurally integrated antenna. The costs of the Smart Gear is around € 700. The innovation offers added value in the development of wireless data transmission to the interior of dynamic metal components. The invention also overcame the challenge of shielding properties of metal. AM enables access to the interior of the component during the manufacturing process and the simultaneous production of several components within one construction process.

Hybrid AM-process



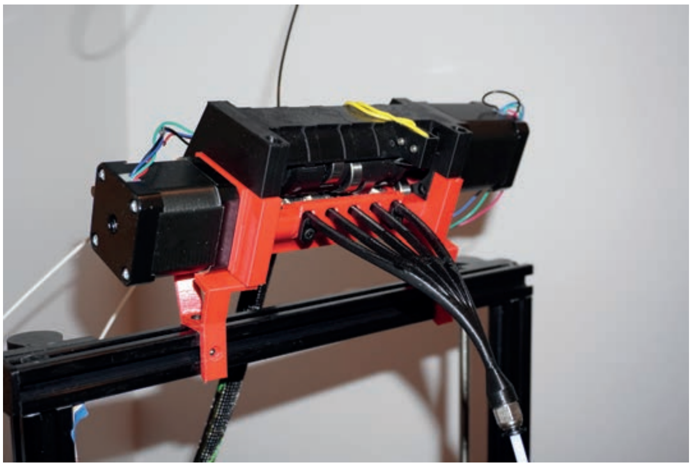
Structure and presentation

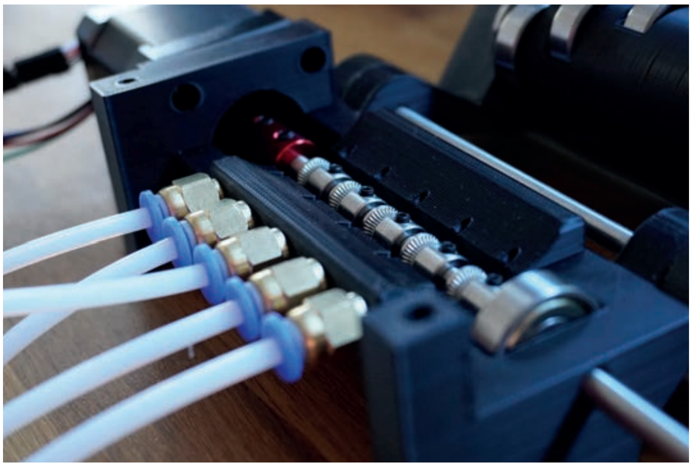




Pierre Masselot

Material Switching Unit





Description

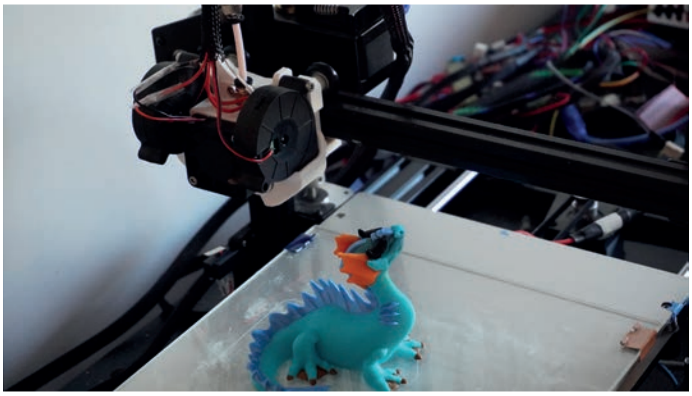
The MSU (Material Switching Unit) is a multi-material upgrade for FDM 3D printers that allows printing with up to 5 filaments. It is based on the design of the MMU2 by Prusa with key changes to improve compatibility and price.

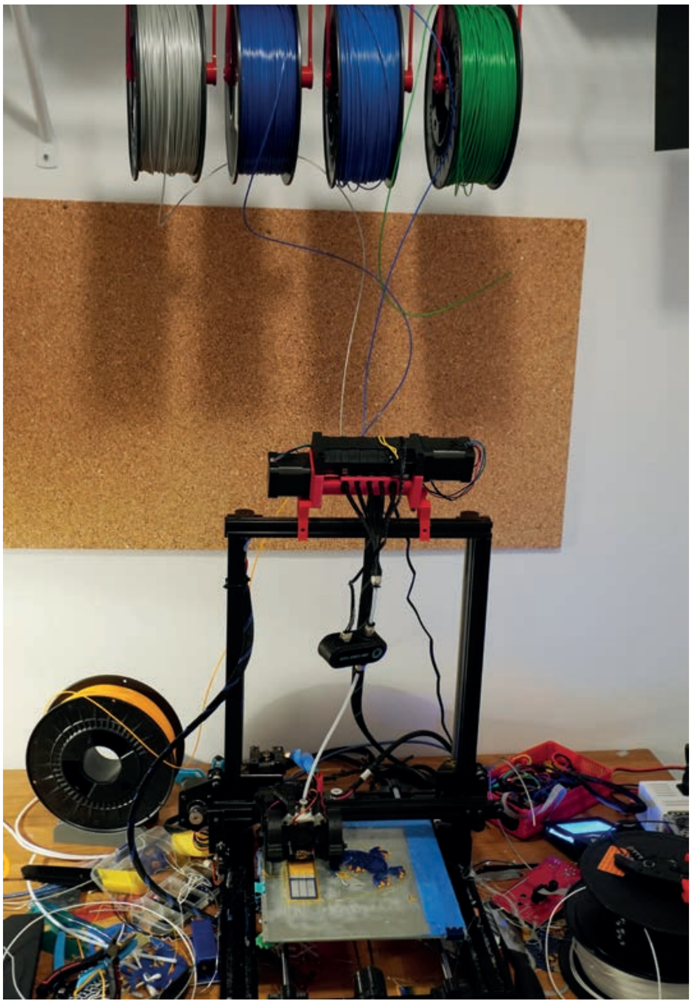
Multi-material 3D printing already has a lot of applications but making it affordable to the masses will be a key element when it comes to the adoption and further development of the technology. The current upfront cost of getting a multi-material 3D printer means that there is still a lack of 3D models specific to multi-material 3D printers, which further slows down the transition to multi-material 3D printing as most designer prefer staying with a single material to reach a broader audience. This upgrade tries to fill in that gap and make multi-material 3D printing available to everyone, the upfront cost is 70 USD which is multiple time cheaper than any other alternative.

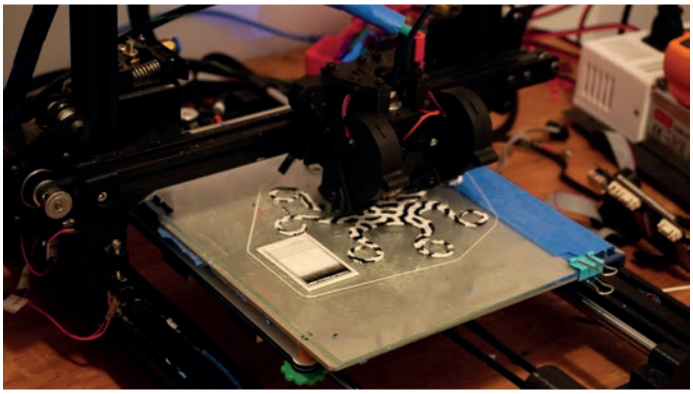
Potential applications would be the combination of flexible and solid materials in compliant mechanisms, soluble supports, carbon reinforcement of parts, and obviously multi-color printing. These are only a couple of examples of what can be done, and the possibilities are limitless. I see people making the most use of this technology for rapid prototyping purposes, allowing the prototyping of over-molded parts and multi-material assemblies in a single print. All those products that would have required the parts to be printed separately and assembled previously can be printed and tested in a couple of hours with multi-material 3D printing.

The design of this device makes it easily scalable, the use of multiple devices on a single printer is possible and creating a version with support for more filaments can be done with a minimal price increase.

The entire project is open-source and a couple of people are starting to build the first prototypes. There is still quite a way to go before this becomes accessible to anyone, there is currently still a lot of tweaking and tuning to do when trying to install this device and it is highly recommended to have programming experience before attempting a build, but my current goal is to remove as much of the guesswork as possible and make things easier to get going. We also have a lot of design improvements in the works. Lastly, the firmware changes might be submitted for potential integration in the official release of Marlin which would make the setup a simple 5-line config change.

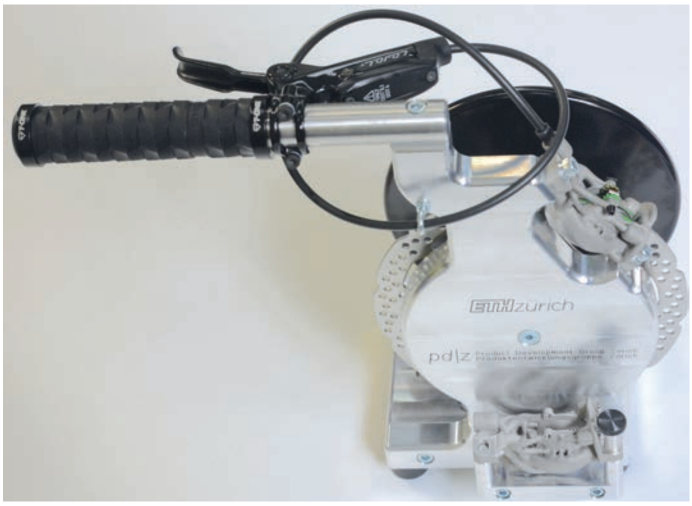






ETH Zürich - Product Development Group Zurich I Aschraf Danun I Michael Wehrli I Remo Elmiger I Ole Müller I Tiago Ogris I Tom Felder I Prof. Mirko Meboldt

Highly Functional Integrated 3D Printed Brake Caliper



Description

As part of a student project of the Product Development Group at ETH Zürich, we designed a highly integrated bike brake caliper for metallic additive manufacturing to demonstrate the free functional complexity potential of AM with three added values: design freedom for internal fluid channels, the functional integration of both, a monolithic compliant membrane and topology optimized lightweight design. Traditional brake calipers are hydraulically actuated using pistons. They consist of two halves that are held together by screws. Unfortunately, the design is prone to leaking. Also, the assembly and bleeding are time-consuming. We managed to reduce the number of parts from eleven to one by replacing the pistons with a compliant mechanism: a thin corrugated membrane. This monolithic design allows the caliper to be printed as one single part with all functionalities integrated. The fluid channels were optimized to trap less air while bleeding. The design is scalable and could be applied to cars or aerospace as well. The -35% lightweight design is visioned to reduce fuel consumption and CO_2 emissions in such an application domain.

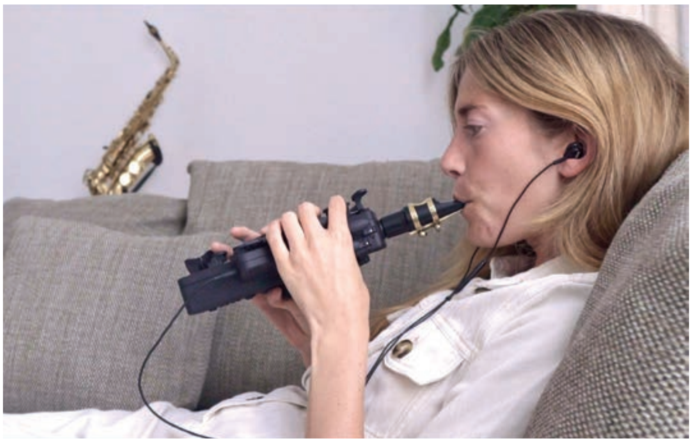
For more information about our highly functional integrated AM part please watch the video: https://youtu.be/mq-pQFMKOqk

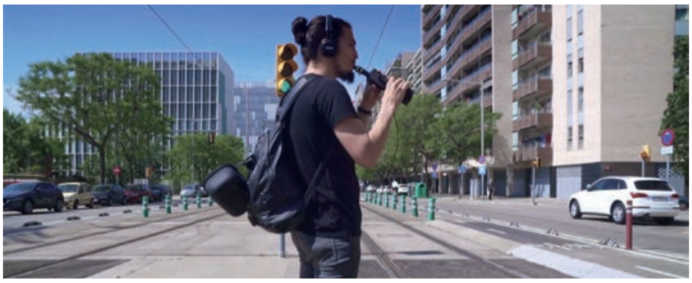
Odisei Music SL I Ramon Mañas

Travel Sax

Description

Travel Sax is the smallest and ligthest electronic saxophone in the world. Designed and manufactured in Barcelona. It has been manufactured with the latestet 3D printed technologies and we have more than 1200 customers all arrond the world. This small MIDI controller can work with your smartphone and with your PC. It uses a standard saxophone mouthpiece and the position of the keys mimic a conventional saxophone as well as the pressure from your breath to determine volume. From now on you will be able to practice anytime anywhere without disturbing others, enabling you to improve your saxophone skills much faster.





ZHAW / Zentrum für Produkt und Prozessentwicklung I Frank Huber I Anton Höller I Philip Dreher I Colin Gubler I Dr. Andreas Kirchheim I Livia Zumofen I Yogesh Katrodiya I Tobias Fritsche I Hanspeter Sautter I Samuel Schweizer

Flexified

Description

This project shows how interdisciplinary use of hybrid additive manufacturing and topology optimization lead to better load distribution and thus to a significant increase in power density in planetary gears.

Planetary gears are used wherever speed and torque need to be efficiently translated. The circular arrangement of the planetary gears and the ring gear around the sun gear enables a compact and lightweight design. Lightweight planetary gears are used in a wide range of applications in mechanical engineering, automotive, aerospace and aviation.

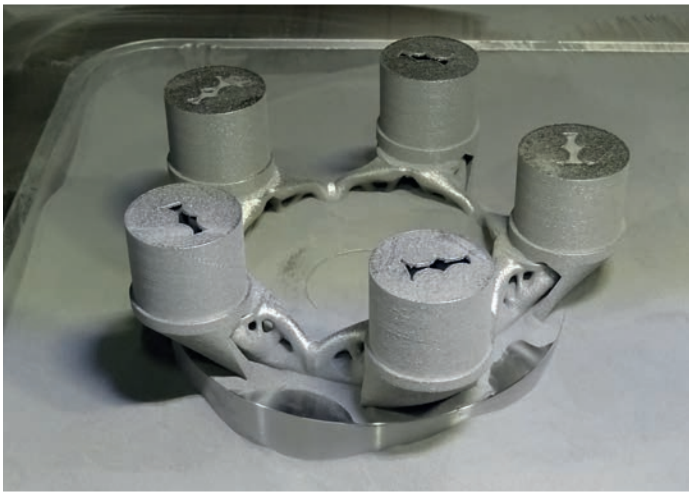
However, due to manufacturing variations as well as different bearing clearances, all planet gears are never loaded equally. In addition, the deformation of the planet carrier or planet pin means that the load is not evenly distributed along the tooth flank. These effects are taken into account in the design of planetary gear units by means of corresponding load factors.

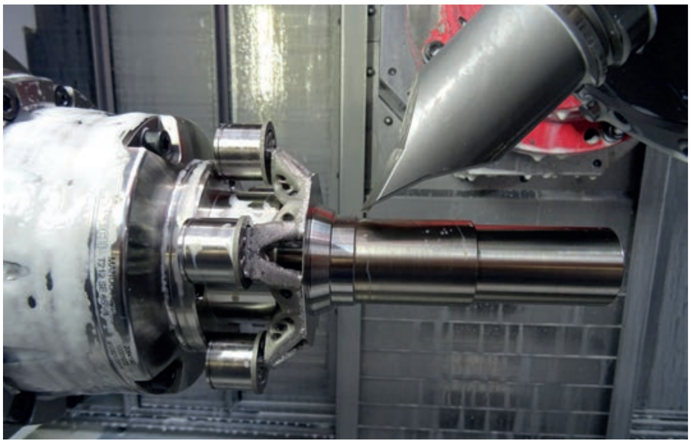
With a flexible design for the planetary pin, the load distribution can be improved and the load factors can be reduced. However, the design is complex and requires a great deal of expertise in design, manufacturing and assembly.

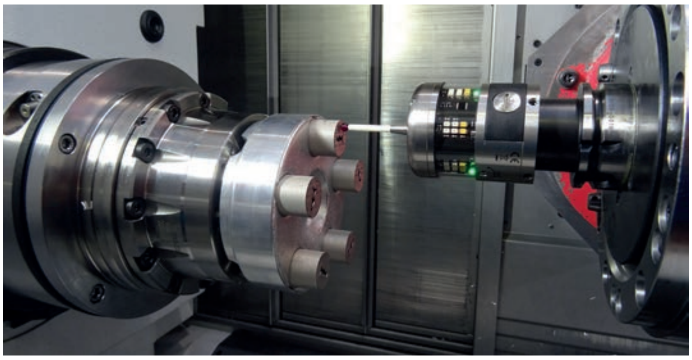
The redesigned planet carrier combines 27 components in one, simplifies the design, manufacturing and assembly. The actual planet carrier was optimized in terms of stiffness, weight (-61.7%) and inertia (-74%) through topology optimization. The flexible planetary bolts for holding the planetary gears are fixed to the carrier. Their complex press-fit connections for mounting in the carrier are no longer necessary. The compliant elements compensate manufacturing inaccuracies and thus enable a higher power density in the gear unit.

The planet carrier was designed as a hybrid component. The complex part, the actual planet carrier with the flexpins, was additively assembled on the shaft stub, which was easy to manufacture. Subsequently, the final machining was carried out on a turning-milling center.

The design was developed within the bachelor thesis by Philip Dreher and Colin Gubler.

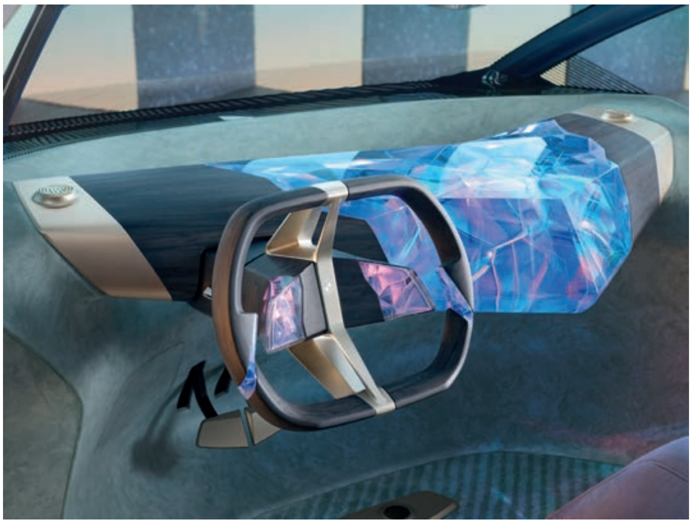


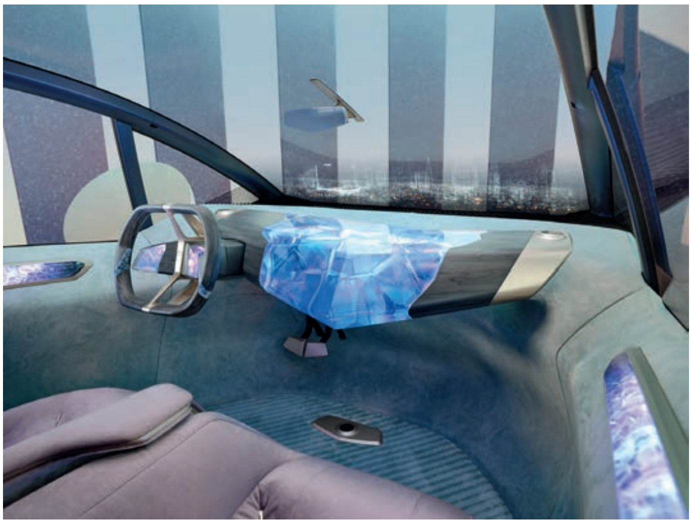




BMW Group I Matthias Seitz I Sophie Richter

Phygital Icon

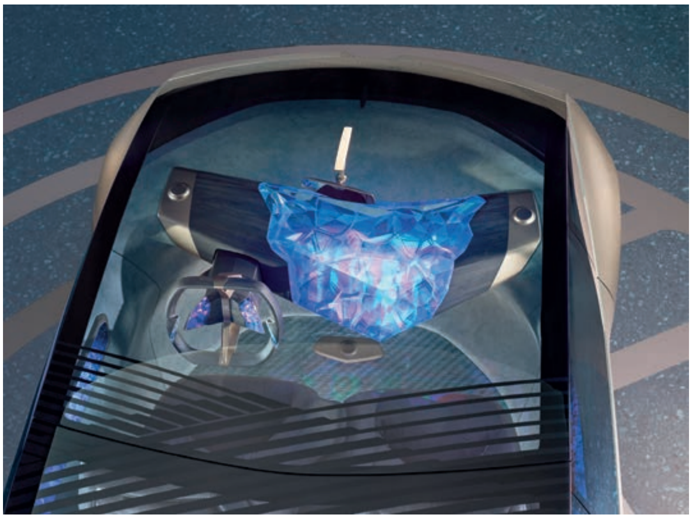


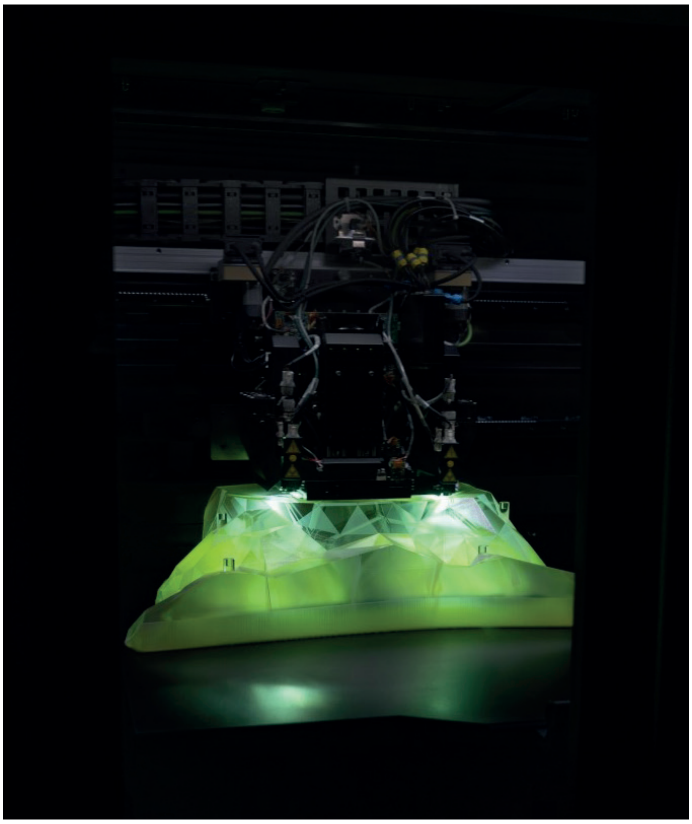


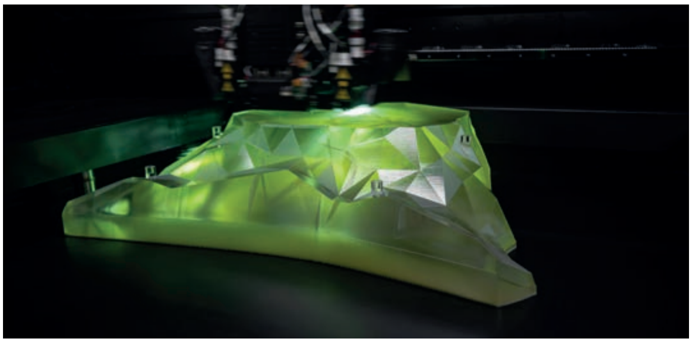
Re-interpreted instrument panel

The global user experience in the BMW i Vision Circular, like its material qualities, deliberately showcases a more distant future with greater in-car intelligence and more sensors that react to the user. Reducing the number of components while also grouping functions together creates a 'phygital experience'. This newly coined term refers to turning digitality into a haptic experience. Depending on the use case, this involves either implementing the underlying technology in a highly integrated, virtually invisible manner as an extension of the 'shy tech' approach or – as demonstrated by the instrument panel – deliberately showcasing it and bringing it to life as an artistic icon.

The classical instrument panel is turned into a next-generation phygital user interface. Here, it takes the form of a hovering, V-shaped sculpture that projects out into the cabin. At its heart is a 3D-printed, crystal body with nerve-like structures running through it, great visual depth and an enthralling lighting effect. This is where the vehicle's "thinking" is visualised, allowing the user to see its intelligence at work. The instrument panel also serves as an area for interaction though, giving form to the fundamental idea of creating experiences that extend far beyond displays and buttons.



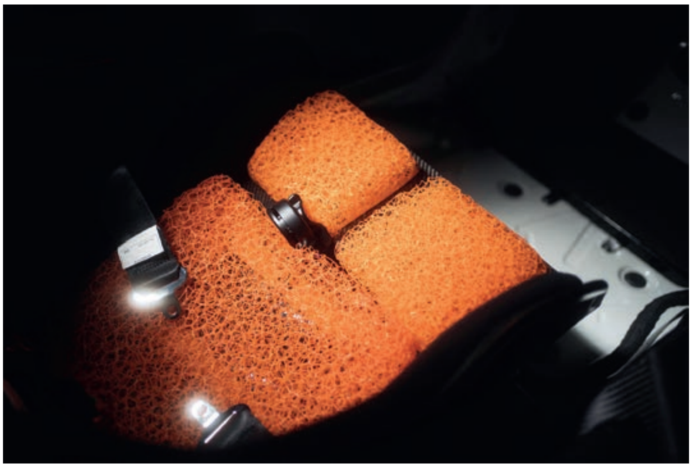




3D FOAM customisable seat cushions

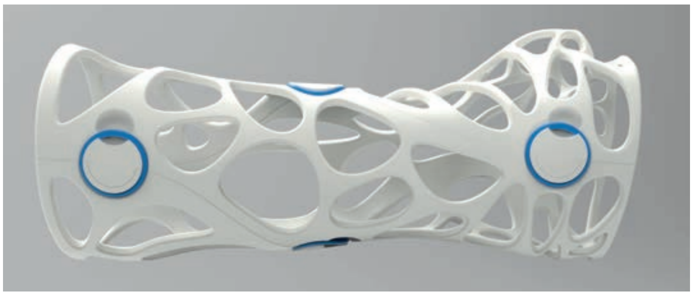
Bespoke 3D-printed parts for the interior

The removable pads on the sport seat, which are likewise 3D-printed and whose innovative structure combines comfort, robustness and modularity. The thickness, hardness and colour of the pads can be adapted as required according to the physiognomy, weight and personal taste of the driver at hand.



Xkelet I Jordi Tura Ceide

Xkelet



Description

Custom immobilizations and orthoses Immobilization system for upper and lower extremities designed to solve problems come from traditional systems such as plaster, fiber, thermoplastics and orthotic products.

Changing the paradigm of the immobilizations systems.
Designed to improve the quality of life of patients, the existing problems of current restraint systems, as well as to reduce the costs and times of professionals in the sector. Solve & minimize the problems that derive from the current immobilization system, such as: Possible ulcers / sores, the exponential loss of muscle mass, etc.

The openings are based on organic forms, with rounded ends to help the evacuation of water and moisture and provide the whole of a great comfort in contact with the skin. Facilitate the rehabilitation tasks of the physiotherapist from the day of the placement, of the cures and monitoring of the wounds, in the case of post-operatories. Totally customized product and made to measure for each patient. This means that the immobilization will be created to the perfect extent of the affected limb, to offer the best possible support. Does not produce any kind of itching or irritation on the skin. Its low weight and design makes living a normal life as normal as possible.

Helicoidal

Patent design of helicoidal cut.

Improves the structural capacity of the product and its resistance to possible impacts.

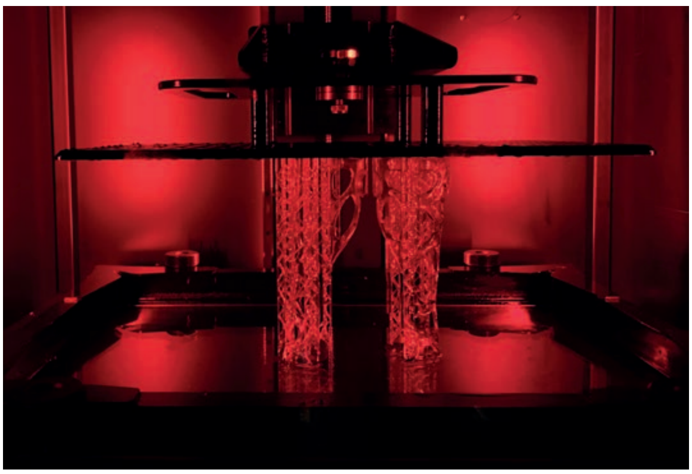
Increases the stability of union between the two pieces and consequently the rigidity of the immobilization, in the case that the patient, performed voluntary or involuntary movements.

Clousure system

Patent system tested and easy to use.

The shore of the o-ring, and the helicoidal cut ,allows us to absob a little of swelling without loosing the structural integrity.

We have 2 patented locking systems. The fixed closing, which is designed so that the patient can not remove the immobilization. And the "Open / Close system" system that allows you to remove it and put it in a very easy and fast way.



Windows design

Was designed to solve some problems becomes from the traditional methods.

Facilitates the access for the realization of the cures, to the wounds or scars of the patient, already well made in the impact of the injury as those carried out in an operative process without having to withdraw the immobilization.

Due to the fact that these wounds can be observed at all times, both by the patient and by the prescriber. Increase the reaction time in front of any possible problem. Infections, swellings, etc ...

Also an advantage for physiotherapists, since they can perform recovery actions, such as: Magnetotherapy, Electrotherapy, etc ... without having to remove the immobilization. The current systems, the physiotherapist can not begin to interact with the patient until the immobilization has been removed.

Last but not least, the mesh design of the immobilization is designed to give maximum comfort to the patient.

DiveDesign I Bionic Pets I Landau Design + Technology I Adam Hecht

Full-limb Prosthetics for Dogs

Description

DiveDesign partnered with Bionic Pets and Landau Design + Technology to re-invent the process of making full-limb prosthetics for dogs using the latest in available fabrication technologies. Previously, Bionic Pets (leading custom animal prosthetics company) made these devices by hand, which took up to 15 hours per device. Because the process was so labor intensive and expensive, very few dogs could be helped. To enable more dogs to receive this potentially life saving device, DiveDesign teamed up with Bionic Pets to re-design the fabrication process utilizing 3D scanning, custom design software developed with Landau Design, and FDM 3D printing . The result of this collaboration was the labor time for one device being reduced from 15 hours to 2 hours, a higher success rate for the dogs, and over 100 dogs receiving a prosthesis in the past year alone, a roughly 400% increase from the prior year.

ATHOS I Emili Taixés I Mar Amengual I Carla Barrientos I Pau Gual I Dídac Llopart I Romina Milesi

ATHOS climbing shoes

Challenge

If you have ever climbed, you will know that climbing shoes are very uncomfortable. They need to go really tight to the feet to have a good performance. Almost all climbers use 2, 3, or even 4 sizes less for their climbing shoes, which can cause important foot injuries over the years. In order to make climbing more enjoyable and healthy, we have designed the first customized climbing shoe to provide better adaptability and better performance for each user.

Context

Athos started at the ELISAVA design university in collaboration with HP and Addition (an additive manufacturing agency from Barcelona). Currently, we are working in collaboration with the IAM3DHUB from Barcelona in order to validate and industrialize our product. In 2022, Athos will make its first sales.

Outcome

Our aim as a company is to create the perfect climbing shoe for each user through co-creation and constant innovation. By using additive manufacturing (AM) technology, each climbing shoe is personalized and customized considering the user's foot shape, needs, and type of performance.

The Athos user's workflow has 3 steps:
1. Feetscan of the user.
2. Customization of the climbing shoes.
3. Delivery to the user.

Additive manufacturing technology

AM is the basis of the Athos foundation. It allows us to unlearn and rethink how climbing shoes are made. The possibilities of AM technology represent a huge advantage over the traditional processes that current brands are using.

Optimization

Thanks to AM technology, the process, machines and materials needed to create each climbing shoe can be reduced by more than 50%. In addition, it allows us to produce just in time, which is a much more responsible method of manufacturing.

Industrialization

For the manufacturing of one Athos climbing shoe, you just need to print the body and assemble the rubber and the pull straps. It is a really simple manufacturing process that can be reproduced and distributed all over the world.

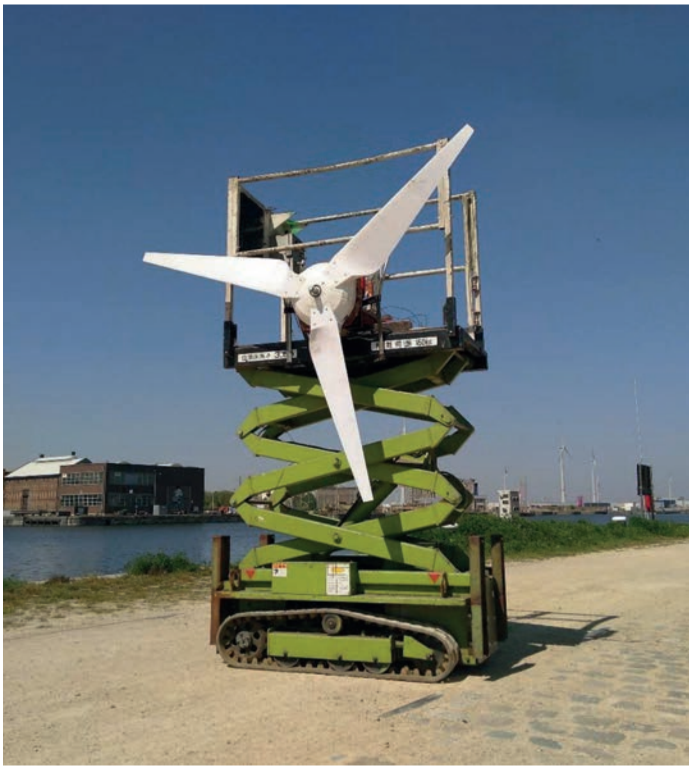
Vegan material

Athos is a vegan product. Nowadays, most climbing shoes are manufactured using animal skin for the body of the shoe. The body of the Athos climbing shoe is made up of TPU, which is a more sustainable material.

Adaptability and social impact

Athos wants to change the way that climbers use and think about climbing shoes to turn them into more healthy ones. The best climbing shoe is not the one that hurts your feet more, it is the one that adapts better to your feet.

Propel-E 450



Propel-E 450: A powerful 3D-printed windturbine

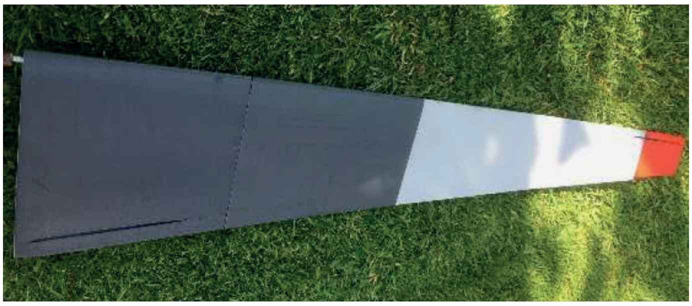
The Propel-E 450 is a fully 3D-printed windturbine that produces enough electricity for the basic needs of a small household, for example powering a fridge, lighting, or charge batteries. The Propel-E 450 can quickly and easily be mass-produced through crowdsourcing. This approach has recently proved to work, where the 3D-printing community resolved the shortage of Covid-19 faceshields. The windturbine can be printed in a few days with any household 3D-printer.

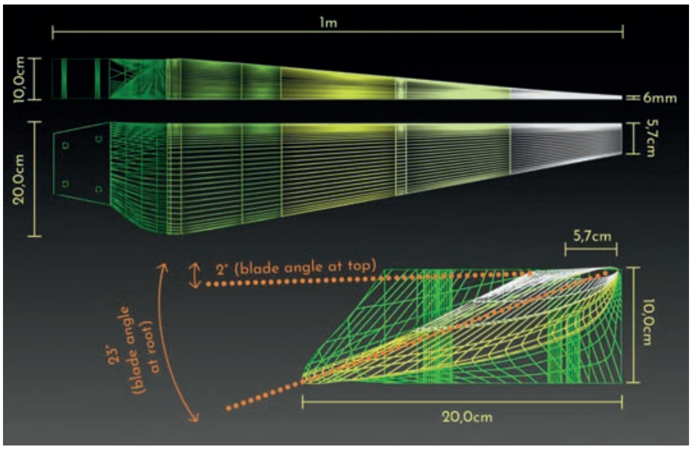
It has a very sturdy design with as less components as possible, while still ensuring maximum power output. The Propel-E 450 is made from PLA, which is one of the stiffest plastics (tensile modulus of 3,5MPa). It also brakes down much faster than regular plastic when composted. If a windturbine would be disposed or broken down, the copper and the magnets can be recycled, and the PLA breaks down. The Propel-E 450 has been tested in different environments, including weather as hot as 38°C.

The 3D-files of each part can be downloaded for free. The pure material costs are approximately 300€.

A first prototype of the Propel-E 450 has been made, and now the final version with improvements like better bearings, better bearing fitting, better weatherproofing, support for different controllers, is ready. When fitted on a tower, connected to a battery and a controller, it is a complete kit ready to be installed next to any off-grid house. (It's not advisable to connect the pole to the dome since noise will travel through the solid structures.)

Build instructions can be found on our website: https://www.fromwastetowind.com/how-to-buildthe-2m-pla-windturbine-1/ and on Youtube: https://www.youtube.com/watch?v=wMi4eIp6J_s





Wing design

We opted for fixed blades, meaning the blades are attached to the axle. Disadvantages of adjustable blades, like being prone to damage and increased material and maintenance costs do not add up to the advantage of having the blade angle perfect everytime. Also, a near-perfect blade can be made by twisting the blade along its length. Because of this, fixed blades have become the mainstream in the wind DIY-community.

To be sure we have the correct twist and taper, we used Hugh Piggot's Blade Design spreadsheet. Furthermore we choose the NACA 4415 airfoil for its good suitability for small windturbines. We modeled the entire blade in Fusion360, with some small tweaks in 3DS Max. To safeguard birds, recent studies have showed that colouring 1 blade black decreases fatalities significantly. One of our Patreon-supporters is currently working on this:
For bats there is only an issue if there is a vacuum behind the blades, which only is the case with big industrial windturbines having blade diameters of >60m. (Bats are, unlike birds, mammals and have weaker lungs that implode after flying through the vacuum. After a few 100 meters, they drop dead out of the sky because of oxygen depletion).

Other studies have selected purple for all 3 the blades as the best colour for both bat and birds (study on big industrial windturbines of >60m).

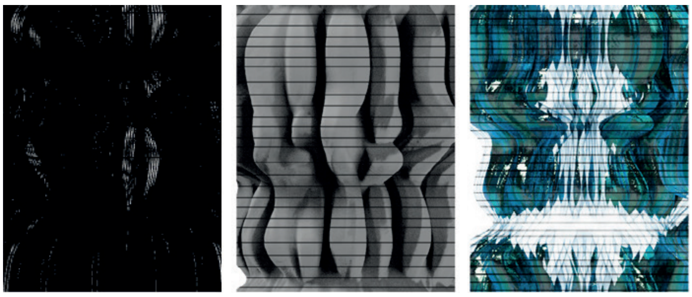
Shuyun Liu I Stefanie Putsch

Glas Clear

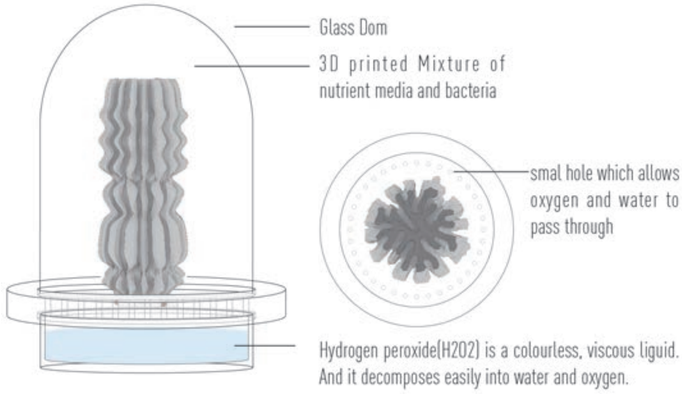
Description

What if we could observe bacteria in a completely different way - up close and accessible? Could a threedimensional, soft and wet structure immitate the body and environment the bacteria normally lives on?

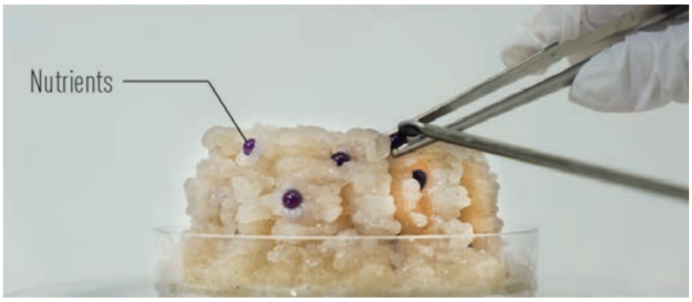
The project "Glas Clear" investigates the fundamental biochemical and structural properties needed to maintain and control microbial activity in new materials. This is done using bioluminescent bacteria, which have a symbiotic relationship with numerous marine organisms. Our goal was to create a structure, that provided the bacteria with nutrients, oxygen and humidity and to give us the oportunity to observe how these parameters can influence the bacterias behavior.



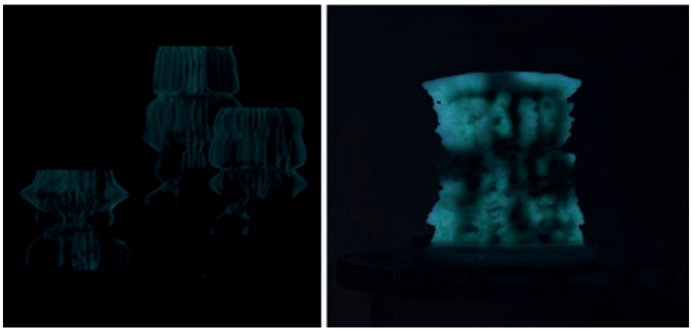
Programming the 3D structure gave us the freedom to experiment with a variety of forms, that our very soft biomaterial could benefit from, to become a tall, stable and three dimensional structure our bacteria can live on.



For printing we mixed applesauce with psyllium husks and alginate. The psyllium husks bind the moisture and form a tough substrate that is ideal for printing.



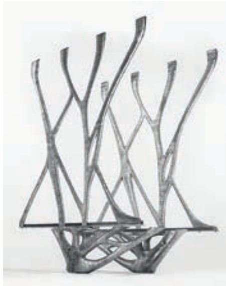
We would encapsulate the nutrients with the help of alginate spheres and then add them selectively to the structure. The bacteria would then already be contained in the pressure mass.



The whole thing is kept sterile and protected by a glass bell. 3D printing gives us the freedom to design a structure to observe the bacteria as it would normally behave only in the deepest ocean. We start to get inspired by thes luminous creatures and we see them up close and glass clear.
left: Visual model with lumineszierende bakterien in darkness
right: Bacteria glowing on a 3D printed medium.

MX3D I Schindler Group I Thomas Van Glabeke I René Backx I Olivier Simmonds I Torsten Nitsche I Jean-François Moulin I Kasper Siderius

Elevate



Description

The Swiss company Schindler and Dutch 3D metal printing company MX3D did an in-depth study into the potential of using topology optimization to redesign elevator carts. MX3D's robotic wire arc additive manufacturing (WAAM) process perfectly fits the geometry freeform and size requirements needed to achieve these optimised design results. The creation was the 3D metal printed 'Elevate' cart.

Led by sheer curiosity, the collaboration focused on exploration and inspiration. Topology optimization can lead to significant weight reduction, and when combined with robotic 3D metal printing, a new manufacturing method emerges that offers shorter innovation cycles and in-house production of customized solutions.

The project was possible due to MX3D's extensive research on aluminum printing for large-scale objects. Using the right printing parameters, several aluminum alloys have excellent post-printed mechanical properties. Here, the alloy AlMg 4.5Mn was chosen for its exceptionally strong material properties.

The project shows the development of 3D metal printing and how in the future it will lead to optimised mechanical structures during our day-to-day lives.

MX3D and Schindler's Elevate project video:
https://www.youtube.com/watch?v=8z-YLcarH5E

Callum Allen

Openpupil

Description

Increasingly, open source systems have enabled users around the world to freely develop and distribute their own products. Initially, this approach was limited to software, however the continued improvement of 3D printing technologies alongside the establishment of online file hosting platforms and e-commerce services has enabled the same model to be applied to the development of physical products as well. From a medical perspective these developments are particularly exciting, as commercially available medical equipment is often very expensive, limiting access for many practicing clinicians, particularly in developing countries.

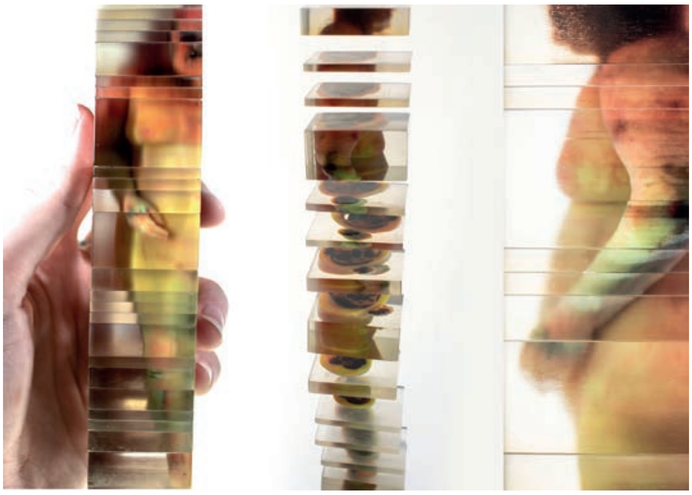
A pupilometer is a device used to measure pupil size under a variable light stimulation or in the dark, enabling clinicians to more-consistently stimulate and measure the pupils under standardised conditions. Commercial pupilometers currently don't provide the blue light required to perform this measurement, while electrophysiology devices capable of the measurement can cost over $100,000. This project explores the challenges and opportunities these emerging technologies and systems provide in the design, development and distribution of a low cost, portable and open source pupilometer in the form of an ergonomic, easy-to-assemble kit set. The Openpupil device is optimised for distributed additive manufacture and assembled with an open source electronic package (webcams, filters, LEDs, battery, Raspberry Pi) to form a robust and functional product - all for less than $1500.

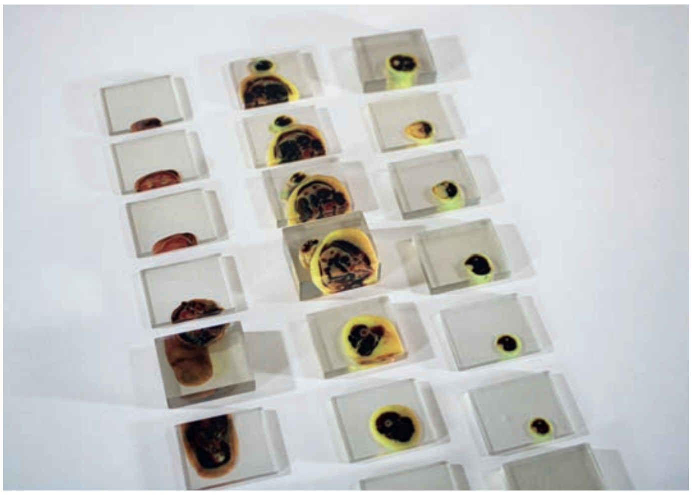
While the immediate goal of the project was to develop the physical Openpupil device, the broader intention is to use open-source technology and systems to democratise interesting new clinical science. A cloud-based data collection system in the form of a desktop/smartphone application would enable clinicians to collect, quantify and share their findings in an online biometric database, laying the foundation for a globally connected research community. This may eventually lead to enhanced diagnostic capabilities in a range of new clinical settings that are yet to be explored.

The project was funded by the Medtech CoRE (Centre of Research Excellence) New Zealand.

Victoria University of Wellington I MADE, School of Design Innovation, Victoria University of Wellington I The MedTech Core Research Network, NZ. I Ana Morris

Visible Woman





Description

The Visible Woman model was created by using serially sectioned cryosection images of a female cadaver produced by researchers working on The National Library of Medicines Visible Human Project (VHP). Using a Stratasys J750 3D-Printer, the Visible Woman was replicated. The Stratasys J750 3D-Printer is a machine used to create lifelike anatomical models with standard or complex pathologies for device testing, surgical training, and patient-specific simulation.

The full data set from the Visible Human Project (VHP) is now publicly available, allowing Morris the opportunity to volumetrically reconstruct the dataset in a new way, never been seen before. The VHP was originally conducted 1990s to obtain serially sectioned images of human cadavers for medical research advancements by the University of Colorado Health Sciences Center. The VHP became a common reference point for the study of human anatomy.

Anatomical medical modelling using traditional mesh-based workflows can be time-consuming. Data loss and segmentation artifacts, due to multiple post-processing steps, can cause anatomically inaccurate 3D-prints. Morris stated that, when using current segmentation workflows, each mesh (STL file) is restricted to one colour and density. However, the advantage of a high-resolution multi-material 3D-printer which allows for control over every material droplet (also referred to as a "voxel") allows semi-automated 3D/4D workflows to create 3D models with unprecedented detail.

Moreover, a model like this highlights the potential of what could come next and will hopefully spark ideas of what could be done. For example, the model could serve as a visual communication tool used in a setting between a doctor and patient, removing all the clinical jargon, helping patients to have a more comprehensive understanding of the human body. In addition, this model brings up questions such as 'how will we preserve people for years to come?'

The detail in the 3D-printed Visible Female shown in this research goes down to 14-micron droplets of material. A total of 5,102 images were processed and sent for printing on the Stratasys J750 to complete the Visible Female 3D-print, resulting in 24 individual 3D-prints stacked on top of each other to form the full 3D-printed Visible Female creating a 3D-print that would be impossible to create using traditional mesh-based modelling workflows.

This project shows the body of a person in extreme detail and in the rawest form. With 3D-printing, we see a lot of stereotypical body forms (generic anatomical shapes suitable for surgical simulation and skills acquisition); while here, we are witnessing a person who has grown up, lived their life, and passed away, so it is a very real cadaver, or synthetic mummification. This form of 3D-printing exploration lies in the intersection between science and art with the hope of catalysing the next wave of the 3D-printing movement.

Stephan Henrich - Robotikdesign und Architektur I Altair Engineering I Stephan Henrich

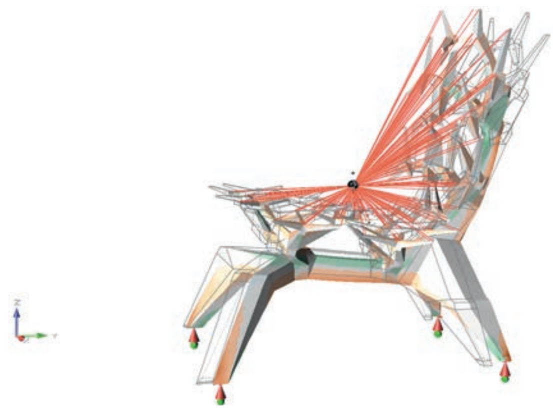
The BushBot-Chair

Description

The BushBot-Chair is a kinetic, so to say passive robotic furniture-design refering to the concept of the Bush-Robot, (NASA-study from the 1990ties), a fractally branching grasping machine, a hypothetical machine able to grasp any bodies regardless its' geometries.

The design is a 'body-egalitarian' approach to furniture and a psychological machine at a time: Every user has to first take a risk in order to profit then of the relaxation. He needs to overcome his/her fear to release the body in a repulsive-looking, spiky bush. The four feet of the chair are supporting four articulated branching-systems of three sub-branchings, ending in 24 contact-stars. Each tree-system has nine pivoting points of one or two DOF, that allow the virtual sitting surface to adjust smoothly to the human body. The chair designed to be manufactured of selective laser-sintered PA12- and flexible TPU-parts.

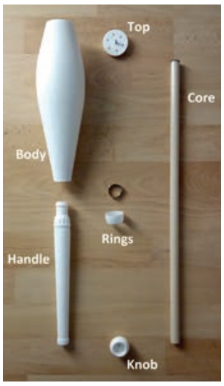
The endings of the branching, touching the body, are realized as a segmented bendable surface, supported by multiple flexing cantilevers to adjust to the human body. The contact-surface is topped by a lamella-system to add anti-skid properties. Structural optimization is used to both minimize material usage and to implement zones of adapted flexibility (at the main-joints performed by integrated quasi-flat-springs) to control the kinematics of the trees.

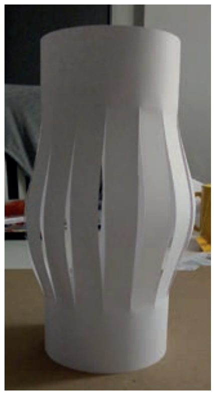


initial raw-design (in Solidthinking Inspire) tension- and compression-zones
Force of 1,5 kN connected to the 24 contact-zones safety-factor 1,6 all supports with two DOF

David Torres

Parametric Juggling Clubs



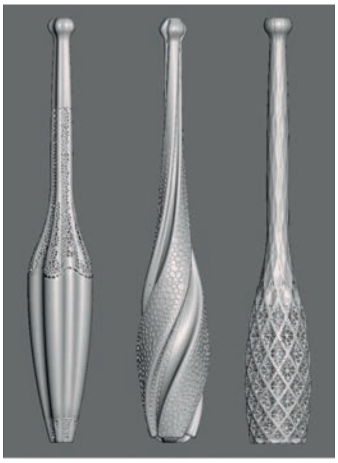


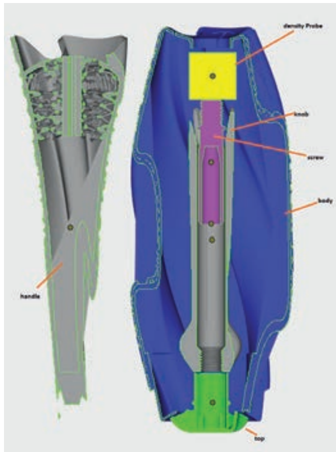
Description

"Parametric Juggling Clubs" was conceived a conversation between material, functionality, aesthetic and manufacturing. The task was to determine what made a good juggling club and incorporate that into the design without the traditional manufacturing constraints. Through research and interaction with fellow jugglers, the following characteristics came up:

- Rigidity: the overall structure has to be rigid for the club to be more responsive I.e. easily manipulated during speed changes.
- Moment of inertia: Personal preference. Dictates how quickly a juggling club spins.
- Center of gravity: usually between half and three fifths of the total length.
- Mass: Between 190 and 250 grams.

The Design encompasses not only the construction of the club under said boundary conditions but also planning how it will be printed to ensure the best quality. Juggling club manufacturing relies partially on handwork, which can affect reproducibility. Customization is limited to colors and few body shapes to choose from. Since club bodies are blow molded, tooling cost would start at around 10k euro. The project takes on the limitations of traditional juggling club manufacturing such as customization, reproducibility and limited complexity.





The key component is parametrization. In the beginning, there is only proportion. A rotationally symmetric surface is created as a guideline. Within this surface a cross-section is extruded along the main axis. The body is hollowed and split in its four components: top, body, handle and knob. Final details include lattice structures and tuning of mass, center of gravity and moment of inertia. Once printed, the parts are assembled around a tubular core/ dowel. Using a carbon fiber core allows for less constraints when redistributing the mass in the printed components. Other cores can also be used depending on the jugglers preferences. SLS technology allows for fine details and good surface quality. The material of choice is PA2200 which has a similar density as HDPE, the original material for Juggling clubs. Dyemansion's deepdye coloring technology offers over 170 RAL and standardized colors for SLS parts. Through color matching, new and individual tones can be created.

Juggling styles are as diverse as the jugglers themselves. Some juggle up to 8 clubs to break world records; some rather focus on manipulation, dance and theatrics. The need for customization makes an opportunity for the parametric club to become a tailor made solution, which goes hand in hand with additive manufacturing.

Cobra Golf® I Parmatech I HP Inc. I Cameron Day I Josh Carroll

Cobra Golf KING SuperSport-35 Putter

Description

Cobra Golf®, a leader in golf club innovation, launched a revolutionary product featuring 3D printing technology. The KING Supersport-35 putter, developed over the past two years in collaboration with COBRA engineers and the teams at HP and Parmatech.

The entire putter body is printed using 316 stainless steel, and then sintered at a high temperature to bind the metal and form the final head part.

New design freedom thanks to Metals Additive Manufacturing (AM)

Due to the advanced capabilities of HP Metal Jet printing, engineers were able to print an intricate lattice structure within the body – a manufacturing feat that wouldn't be possible using traditional casting or forging methods. The lattice fine tunes the feel and optimizes the distribution of weight within the putter head to create the highest moment of inertia (MOI) without the need for additional fixed weights. During the final step of the manufacturing process, the surfaces of the putter are precision milled using a Computer Numeric Controlled (CNC) machine to ensure precise shaping and detail while adding the finishing touches to the cosmetic.

AM-enabled innovation to unlock ultimate performance

The Supersport features a high MOI heel-toe weighted design for maximum stability, and a plumber neck hosel with a 35-degree toe hang suitable for slight arc putting strokes. In addition to the 3D printed design, the KING Supersport-35 Putter features a face insert designed in partnership with SIK Golf, which utilizes their patented Descending Loft Technology (DLT) to create the most consistent and accurate roll on every putt. Their signature face design utilizes four descending lofts (4°, 3°, 2°, 1°) to ensure the most consistent launch conditions for every putting stroke.

The exciting partnership, born out of work with SIK Golf partner and COBRA ambassador, Bryson DeChambeau, yields flatsticks that not only provide superior stability and consistency due to 3D printing technology but also significantly improved consistency and roll performance.

"I've had a lot of success over the years with my SIK putter and was really excited to work with COBRA to develop a new way to manufacture equipment and bring this new putter to market," said DeChambeau. "HP's Metal Jet technology is an incredibly advanced production method and very exacting, which is pretty critical in golf equipment. I think golfers of all levels will benefit from the combination of COBRA's high MOI design and SIK's Descending Loft technology."

"The putter design benefitted from several of the advantages of HP's Metal Jet binder-jet process. Our engineers worked closely with Cobra to strategically shape the putter to optimize weight distribution, stiffness, and performance of the putter," says Rob Hall, Parmatech President.

Innovation agility made possible with AM

"Being able to produce design iterations quickly was key to the success of the project," adds Joshua Carroll, Sr. Project Engineer and Additive NPI Manager at Parmatech. "We produced 57 different design iterations to get the final putter design just right—focusing on the moment of inertia and forgiveness and feel of the putter, along with giving the putter a good sound when it strikes the ball."

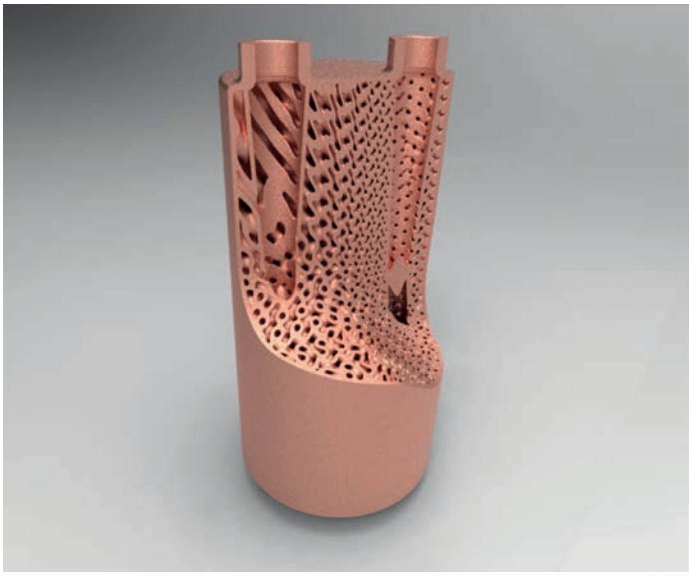
In the past, it wouldn't be practical or cost-effective to produce that many prototypes during development. An added advantage of the HP Metal Jet Additive Manufacturing innovation process is that it provides the ability to produce multiple designs concepts in a single print run.

"This first of its kind putter is a shining example of the disruptive design and production capabilities of HP Metal Jet 3D printing technology. Cobra's commitment to innovation and competitive excellence combined with the technical expertise and leadership from Parmatech has led to a breakthrough design win for golf fans around the world," said Uday Yadati, Senior Director of Product Management, Strategy and Business Development, Metal Jet, HP Inc.

Watch videos to see innovation in progress with Additive Manufacturing:
Cobra Golf Reaches the Next Level of Adaptability with HP Metal Jet
Cobra Golf Achieves Scalability from Prototyping to Production with HP Metal Jet

Aidro - Desktop Metal Company I Tommaso Tirelli

Toucan Beak



Description

Key elements of the idea/problem: Bio-inspired design and manufacturing
Heat Exchanger (HX) with metal Additive Manufactured (AM) micro-channel structures, designed through Multidisciplinary Topological Optimization and Machine Learning simulation (AI) enabled by High-Performance Computers.

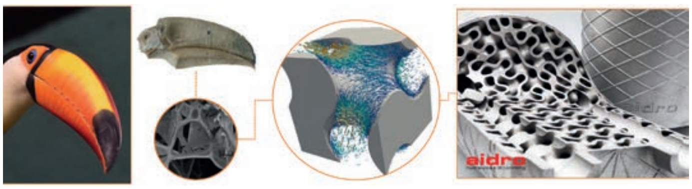
Outcomes
Highly efficient, low weight, low carbon footprint HX solutions, through very innovative advanced design process. Digital inventory and distributed manufacturing readiness through AM. Increase energy efficiency for existing systems without system layout changes or for spare parts

Goals
improve heat exchange, reduce pressure drops, reduce weight and space, on a printable LPBF solution

Market & Business opportunities
HX EU Market value*: 1.8 b$ (2015), 4.5b$ (2027), CAGR 12.1% (2020-2027). Profitability driven by solutions with high degree of customization and flexibility for high end applications; extension of partners' core business (*source: Grand View Research, Inc)

Partnerships
Co-funded R&I project (EU: 3DP Pan, FF4EuroHPC / Italian Government: CIM4.0, MADE). Partners: Optimad Engineering, EOS GmbH, CINECA

Advanced Optimized Solutions for Additive Manufactured Lightweight and Highly Efficient Heat Exchangers



Bio-inspiration

The Toucan Beak is:
- Lightweight but stiff, thanks to controlled and variable porosity (Nature's Topological Optimization)
- Integrates multiple functions, including a Controllable Vascular Heat Exchanger

Design

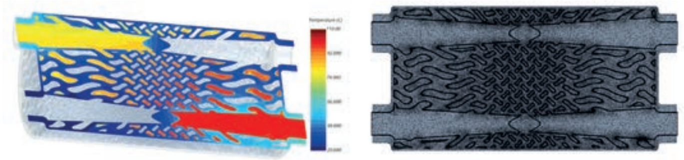
Highly Innovative approach. Multi-disciplinary Topological Optimization with advanced simulation tools, Machine Learning and Hight Performance Computer deployment. Increased surface for same volume and controlled porosity = thermal efficiency increase and lightweight solution

Manufacturing

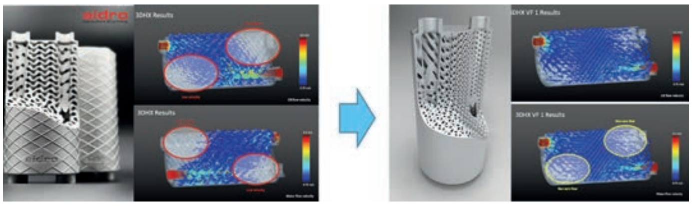
Laser Powder Bed Fusion allows to manufacture micro-channel complex structures. Readiness for digital inventory and distributed manufacturing, i.e. in proximity of the end user site with extremely short lead-time. Enables Integration of multiple functions in a single part.

Variable Porosity

= Frequency variation of gyroid, to address the fluids in all volume available and increase heat exchange



Highly Innovative Design approach.
Multi-disciplinary Topological Optimization with advanced simulation tools, Machine Learning and High Performance Computer deployment.
Increased surface for same volume and controlled porosity = thermal efficiency increase and lightweight solution

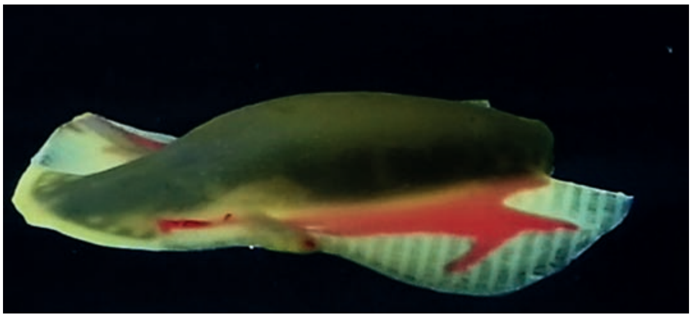


Solution 1.	Solution 2.
Gyroid Surface with constant Frequency	Gyroid Surface with Variable Frequency
Cooling capacity 0.21 kW/°C	Cooling capacity 0.33 kW/°C
Oil pressure loss 0.12 bar	Oil pressure loss 0.23 bar
Water pressure loss 0.1 bar	Water pressure loss 0.15 bar

-> Variable Porosity HX improves thermal performances

Bio-inspired Robotics and Design Laboratory - Singapore University of Technology and Design I Washington State University I University of Colorado Denver I Pablo Valdivia y Alvarado I Narasimha Boddeti I Tien Van Truong I Vincent S. Joseph I Thileepan Stalin I Theo Calais I Shien Yang Lee I Martin L. Dunn

Bespoke 3D Printed Soft Robots



Description

Material properties and composite structures play key roles in tailoring the performance of 3D printed functional devices such as Soft Robots. Unfortunately, current design (i.e. traditional CAD) and fabrication approaches limit achievable complexity and functionality in these two categories and hinder the performance of 3D printed functional devices or products.

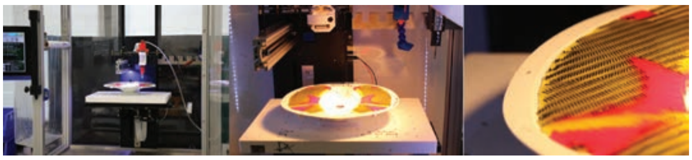
This project takes a systems level approach that allows innovative design and direct fabrication of novel soft composite structures. The process uses computational topology optimization to determine the required 3D composite structure of soft hyper-elastic bodies.

Design

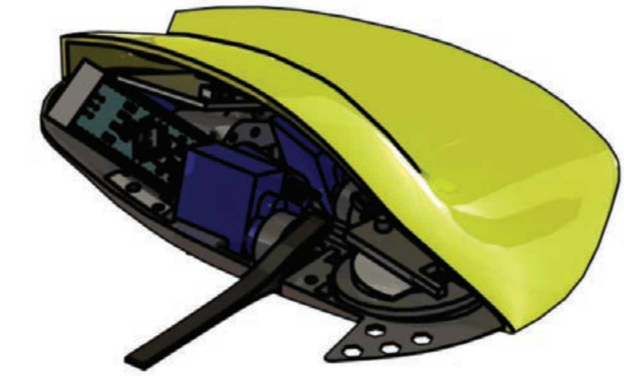
As an example application, the figures on the right show the design of a Soft Batoid-like robot (TOP) and the design of the optimal 3D composite structure for fins that enable high propulsive performance (BOTTOM).

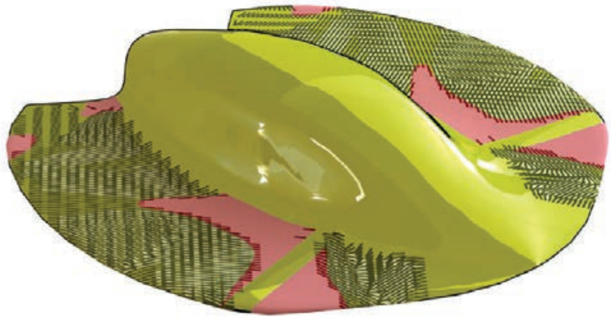
Fabrication

The direct fabrication of the soft composite structures using an all-in-one fabrication workflow with resilient silicone polymers enables precise tailoring of mechanical properties. By applying this approach to the design and fabrication of an underwater batoid-inspired soft robot, significant swimming performance improvements are demonstrated. The pictures below show the fin fabrication process via Direct-Ink-Writting (DIW) and embedded 3D printing (LEFT & CENTER) and a detail of the fine features of the 3D composite structure of the fin (RIGHT).



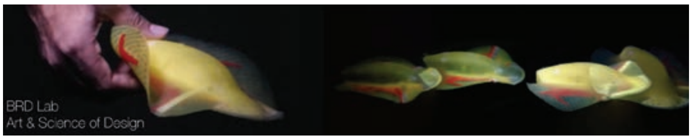
The design and fabrication approaches developed for this project complement each other in a novel way to provide a higher degree of customization and functionality in silicone based 3D printed functional devices. Our computational design approach enables optimization of the material property distribution to yield desired body kinematics at a new level of complexity. The required material distributions are translated into equivalent soft composite structures and the resulting tailored robot kinematics enable performance not achievable using traditional fabrication approaches.





Results

An optimized composite prototype (images BELOW) displays 50% faster swimming speeds, 28% faster turning rates, and 55% smaller turning radii than un-optimized benchmark prototypes.



Fraunhofer IGD | Lubna Abu Rmaileh | Alan Brunton

Displaced Signed Distance Fields

Description

As the resolution and accuracy of 3D printers increase, accurate reproduction of finely detailed and smoothly curved surfaces becomes increasingly realizable from a hardware perspective. However, creating input geometry at device precision using triangle meshes, the de facto standard, results in tens of millions of triangles, bloated file sizes and the storage, transmission and processing challenges that come with it. Further, achieving device precision at different print sizes requires different numbers of triangles.

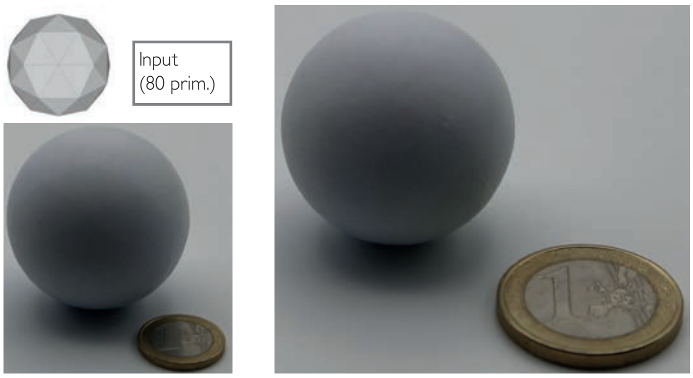
Figure 1: A 13-cm teapot printed with a dishcloth displacement map (left) and without (right). The fine-scale surface detail and visual realism costs less than 1MB in extra storage.

Displaced signed distance fields are a novel implicit representation, which encodes geometry at the precision of the printing device and can be efficiently computed from a low-polygon mesh and a displacement map, which stores fine-scale geometric detail more compactly than a mesh. Such representations are common in the entertainment sector (films and gaming), which is making increased use of graphical 3D printing. This makes it increasingly important to directly, automatically and efficiently support this type of input. Since models from these applications are designed for on-screen display, not physical fabrication, they are often composed of open, overlapping surfaces and decals. The mesh in Fig. 2 is comprised of disjoint patches with small gaps in between. Thus, robust processing is key to automation.

Input Print

Figure 2: A model comprised of disjoint mesh patches, a displacement map, and a color texture map (left), and the resulting print using displaced signed distance fields (right). The total geometry storage is only 2MB.

Over half of parts produced by additive manufacturing are either functional parts or functional prototypes. These are often designed as parametric patches, then tessellated into polygonal meshes, which introduces an error. This error can be reduced by tessellating into meshes of curved, instead of flat, triangles, which scales much better in that the approximation error is less sensitive to the size of the printed part. Existing approaches to fabrication with curved triangles are based on subdivision, requiring different levels of subdivision for different print sizes. Displaced signed distance fields can realize curved triangle-based shapes to printer resolution without subdivision or other tessellation refinement (Fig. 3).

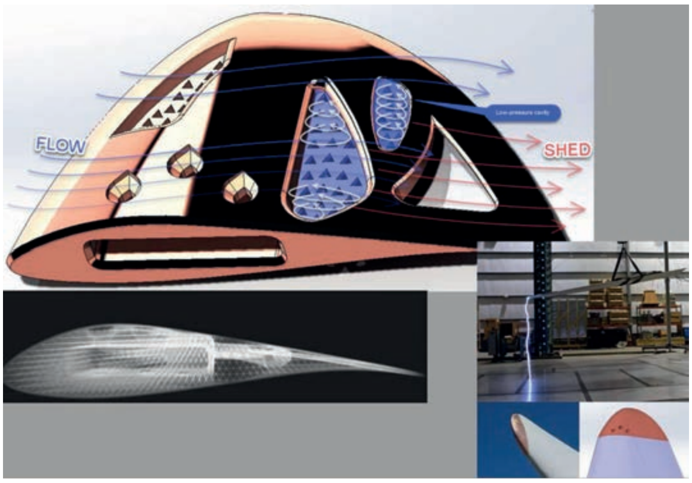


3cm print 5cm print

Figure 3: An 80-curved-triangle approximation of a sphere can be used to approximate the sphere to printer resolution at different print sizes using displaced signed distance fields.

Displaced signed distance fields work by combining discrete, voxel-to-voxel distances, which can be computed very efficiently, with a sub-voxel precise displacement field, which encodes the offset from the voxel representation to the true surface. This allows efficient computation, where the run-time depends only on the print size (number of voxels). Robust sign estimation, including handling of geometric structures below the voxel size, allows displaced signed distance fields to be computed robustly for challenging input, which are not necessarily printable by traditional techniques. For algorithmic details and more examples, please refer to our paper.

Direct Digital Manufacturing



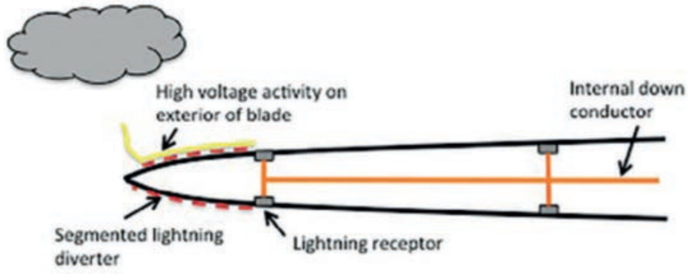
Vestas's Additive Manufacturing Process Innovation

Additive manufacturing has the potential for transforming manufacturing and global supply chains by producing parts where and when they are needed. AM has succeeded in making inroads into many organizations based on the promise of providing fast, cost effective alternatives to traditionally machined custom parts. Despite this success, the beneficial impact that AM has on overall operations in these organizations has often been constrained by the limited availability of people with core AM competencies for managing part production in proximity to point of use. Supply chain managers to equipment operators to new product introduction designers in their organizations in need of 3D printed parts have had to rely on an individual's or small AM team's limited availability and printer resources. This has meant that scaling AM to benefit entire organizations has been difficult.

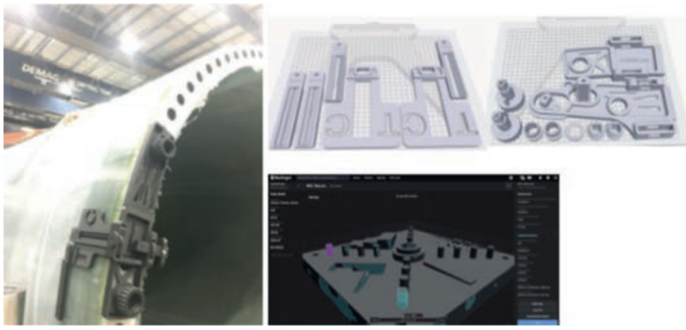
For Vestas, AM is the hub of its Digital Direct Manufacturing (DDM) vision that starts by digitizing its supply chains by making tools and parts, on-demand, with no lead-times and at a fraction of the cost. The company is implementing rapid response systems so central teams and factories can support one-another in an agile way. Taking advantage of innovations in cloud-based AM software solutions, Vestas is working to achieve its DDM vision for managing AM part production on a global scale. This involves creating an end-to-end process powered by Markforged's printer and cloud-based distributed manufacturing software solutions. First, Vestas is equipping each of its facilities around the world with Markforged's 3D printers and leveraging Markforged's Eiger Fleet software to centrally manage users, devices and production workflows globally to produce high quality and performance parts whenever and wherever they are needed. Vestas is using Markforged's Blacksmith software for automated part inspection and analysis, replacing manual quality certification processes, for ensuring compliance with strict part quality and corporate requirements. Blacksmith is an adaptive manufacturing platform that connects part design, production and inspection with a powerful AI. Vestas partner Wurth provides delivery and support for local printers, spare parts and materials.

Second, Vestas is unlocking the benefits of AM for its entire organization by embedding access to AM part production into several of Vesta's key business systems through the use of Eiger Fleet's industry standard RESTful APIs. This integration and workflow automation enable anyone in the organization with permission to select a part in a digitized Kanban inventory system to automatically 3D print a part on the printer at the requester's facility with the click of a button from within their corporate Asset Management or Enterprise Resource Planning systems.

Vestas has initially identified several parts that are capable of being produced on a global scale using AM because of the company's new innovative end-to-end process. One example of a product with a complex design is a marking tool critical for proper assembly of blades on its wind turbines. Previously, the part required a lead time of three weeks and cost thousands of dollars. Now, a fiber-reinforced composite marking tool can now be 3D printed and automatically quality inspected with Blacksmith at any Vestas manufacturing site, saving time, costs and human capital, in a little over one day and at a cost of under $100. A second example of a complex design is a new metal copper lightning receptor tip for its wind turbine blades to be manufactured at each of its blade manufacturing sites using optimized topology only capable with AM for maximized current conducting resilience and heat dispersion to better protect their blades while in



When an unprotected wind-turbine blade is struck by lightning, its temperature will rise (as high as 54,000 F) and severely damage the surface of the blade. It may also melt or crack the blade's leading edges. Here, the image shows the entry point of a strike.



service. What this means for Vestas and other organizations that follow Vesta's example is the ability to overcome the obstacles that have historically limited the benefits of AM within organizations to a select few by unlocking the benefits of AM to anyone with permission on an enterprise and global scale. A central team can manage a distributed or global workforce and oversee AM production anywhere in the world to 3D print a wide variety of centrally-approved parts faster and at lower costs. Part design experts can be given permission to make improvements to parts available for printing while others can only request that an approved part be printed and cannot make unauthorized changes. Blacksmith's automated part inspection and analysis ensure that parts are printed with the required tolerances and specifications.

By enabling Vestas to send a wider variety of its part designs digitally for local printing faster and at lower costs instead of shipping physical parts on planes, trains, ships or trucks, AM is contributing to helping Vestas achieve its sustainability goal of net zero decarbonization by 2030 and Industry 4.0 digital stream, digital twin and IoT goals.

EDAG Engineering GmbH I Martin Rüde I Fabian Baum I Sebastian Flügel I Ricardo Hagemann I Simon Merget I Stefan Friedrich

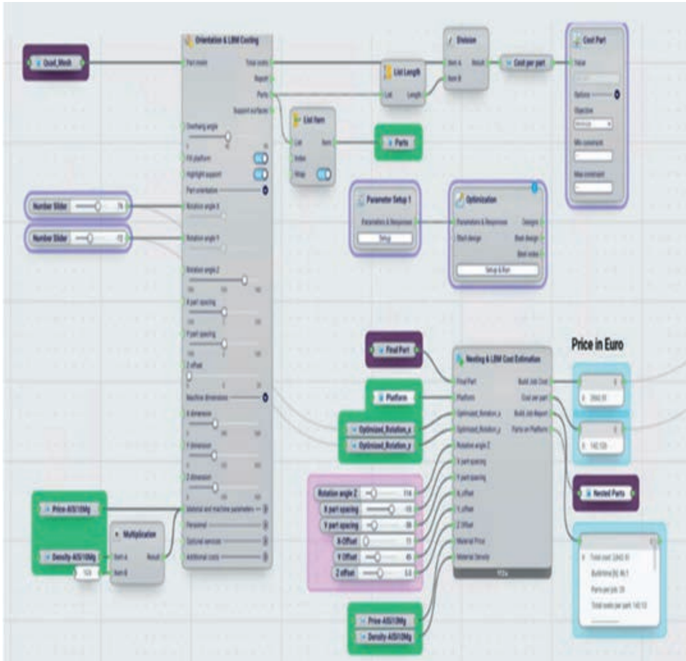
Automotive Bracket using agile development process

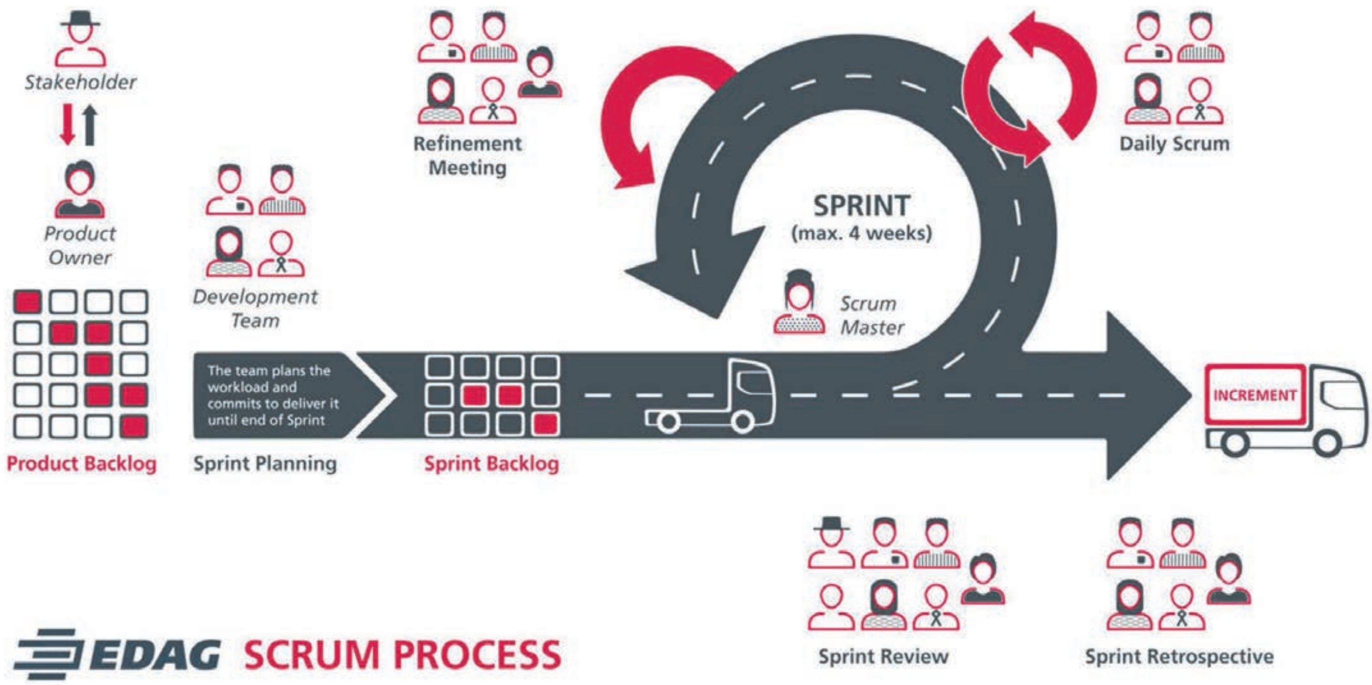
Description

The additively manufactured EDAG bracket for a rear spoiler combines an attractive design, various customization options with an ecologically sustainable production process thanks to a support-free design.

We found, that using principles of agile working and Scrum, the development process of additively manufactured components experiences a significant increase in efficiency. The direct involvement of the production partner leads to a very early and continuous improvement of the maturity level of the product. The approach of having the current development status manufactured after each individual sprint allows the team to immediately investigate and experience the quality of the product and optimization potential can be recognized and optimized directly. That way, potential issues in the manufacturing process can be resolved at an early stage, compared to pretty late and expensive changes in the conventional development process. The result is an accelerated, joint and efficient development process for additively manufactured components in which the project participants of the READDI research project, funded by the BMBF, were also involved from the beginning.

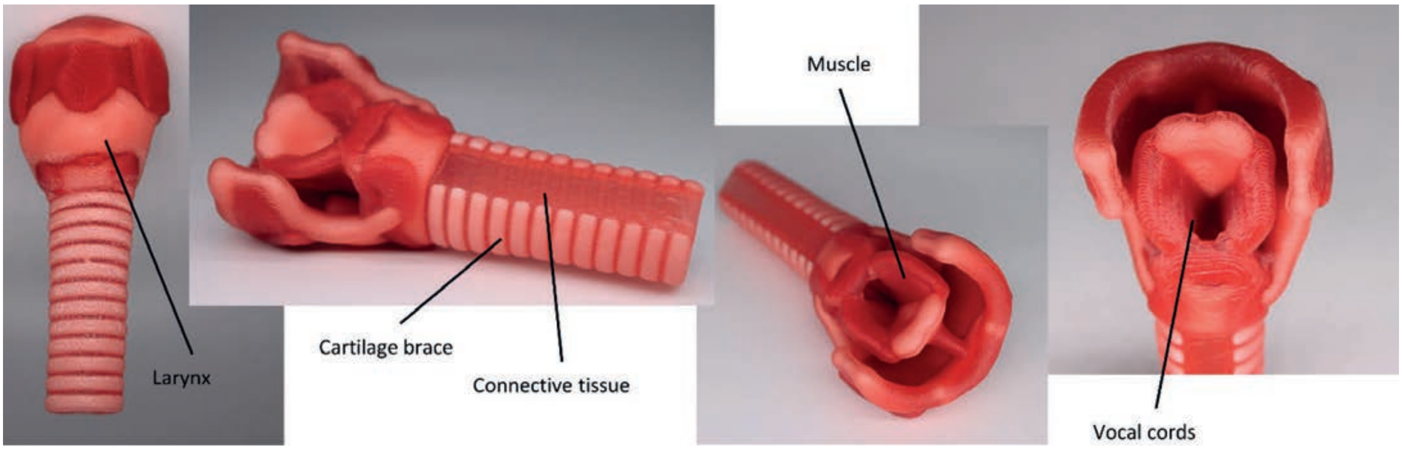
In a variant of this approach, the efficiency and variability of the design process can be further improved by the use of innovative software tools. The component is not designed in a conventional. With this approach a "component DNA" is generated with the help of a visual programming language. This "DNA" controls the parametric geometry creation, taking into account the respective boundary conditions and requirements for the respective component.





ANAMOS GmbH I Hannah Riedle I Matheus Neri

Intubation simulation model



From design to 3D printed functional multi-material model

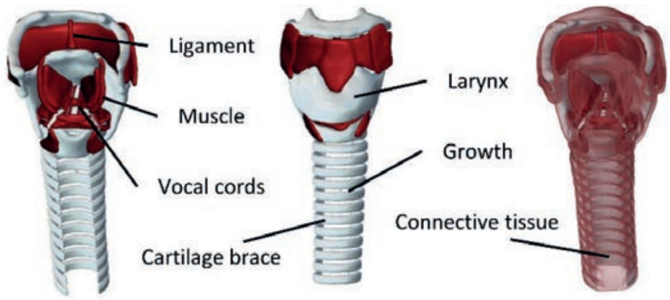
Background
Innovative anatomical models open up new possibilities in the simulation of medical interventions due to their realistic functionality and haptics. By substituting direct human application, new training and evaluation environments are created, leading to increased efficiency in medical education and training, medical device development and research. Compared to biological models, such as cadavers or animal models, the artificial ANAMOS models are always available, easy to store and handle, and can also represent any anatomy and pathology.

Innovation-driven design process
The ANAMOS intubation model depicts part of the trachea and larynx. The model was created using a novel generic design method from medical CT image data, which allows realistic mapping of the cartilage brace, larynx, muscles, ligaments, vocal cords and connective tissue. The design is designed for multi-material 3D printing, which allows complex anatomical geometries to be maintained and the component to consist of several different functional components. The process and validation of the design is done through close collaboration with medical professionals and medical device users to ensure both anatomical correctness and functionality in use. In addition, the design requirements of the 3D printing process are taken into account to ensure correct manufacturing.

The innovative ANAMOS design process allows the model to be quickly adapted with regard to any different sizes, anatomical variants and clinical pictures. The presented version shows a model of a healthy anatomy. The crosssection of the trachea is symmetrical and there is a small non-pathological growth between the fourth and fifth cartilage braces.

Functionality through the use of multi-material 3D printing with silicones
The focus of the model is on realistic functionality. 3D printing from silicone using ACEO® technology (Wacker Chemie AG, Munich) allows the elastic properties of the fabric to be reproduced while retaining the geometric complexity. The model has been created using a multimaterial process that allows simultaneous fabrication with silicones of different hardness and color. The white components of the model represent cartilage and bone and are made of a harder material than the red muscle tissue and the even softer red translucent connective tissue.

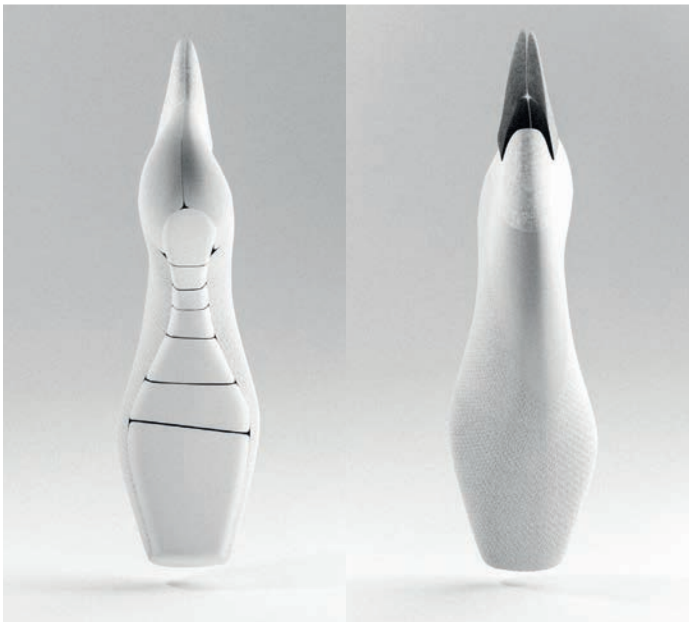
The model can be used to simulate the intubation of a patient. It can be used to perform the puncture between two cartilage braces and the actual intubation as well as to simulate the monitoring of the procedure by a bronchoscope and its navigation through the vocal cords. Such a simulation can be used, for example, for training purposes of medical personnel or for the development of newer medical products for intubation or bronchoscopy. This can increase efficiencies and improve patient care. The functionality of the model in this form is only possible through the unique combination of the innovative ANAMOS design process, 3D printing with multiple elastic silicones and the integration of the users' requirements.



ANAMOS

act'ble GmbH I Sophia Lindner

new pointe shoe sole



Description

Developement of a tool, that's made to move. Moveable in itself due to the geometry. Enabling perfection of aesthetic movements

As a young and dynamic innovation team we re-think one of the most iconic, aesthetic, and powerful sports: ballet. act'ble is a young company creating a new art of movement. Design and Research together with high level athletes leads to the developement of a new pointe shoe for classical ballet and contemporary, that lasts 5 times longer than conventional pointe shoes and dramatically reduces physical pain. We want to enable dancers to make a difference in their performance, live and world. Through our patented concept of a 3D printed Sole combined with an upper we create new possibilities of movement and individual artistic expression.

State of the art

Pointe shoes are made by the most elaborate handwork. In over 100 steps a shoe is made from several layers of linen and glue, which is then oven-hardened for 24 hours. The durability of a pair of shoes is 1 day in professional sports, which puts the dancer at extreme health risk. The Royal Opera House in London, for example, invests 250,000 EUR in pointe shoes alone per season.

Thanks to 3D scans, 3D printing and functional knitting, we develop a performance she that fits perfectly

To eliminate the conflict between the necessary flexibility and stability, the sole has cuts at the bottom. They allow free movement for the upward and downward rolling movements of the foot, where physiological walking is not possible with conventional shoes. On the other hand, for standing on the toes, the optimal support function is ensured by the segments closing and blocking. According to a modular system, the sole and the upper shoe can be exchanged later.

Developement

In 3D printing we have found a tool that offers the same precision and individuality as the athletes themselves. Mass personalisation and motion capture also open up possibilities that were previously unheard of in this industry. In over a hundred iterations, we 3D printed an individually generated prototype every 1 to 2 days, further optimised it and tested it with high-level athletes from the surrounding state theatres and companies with extremely positive feedback. Due to the high precision of the FDM process, we were able to develop a performance sole in rapid prototyping that never existed before. The 200-year-old traditional pointe shoe is completely rethought.

Fluent transition from prototype to series product

The next step is to optimise the sole geometry for the SLA process in order to produce 3D printed soles that will also be sold directly to customers.

Scenario "Beta-Testathlete": Permanent optimisation through direct customer feedback

The first 3D printed act'ble shoes will be available for purchase in early 2022 as part of a beta study. For high-level athletes, there will be the possibility to make adjustments to individual needs in terms of performance and health. Thanks to mass customisation, dancers will be able to find a tailor-made answer to their individual requirements. It is no longer necessary to test/ consume a large number of shoes in order to find one that comes close to fitting. 3D printing + form-knitting offer the basis to produce without waste.

User feedback

Our vision is based on one of the greatest cultural assets that has always shaped humanity: Dance. In addition to the world's leading Stuttgart State Ballet, we would like to set another milestone in the region and further develop this cultural treasure and make it available to dancers worldwide. Quote from our survey of a dancer from the New York City Ballet: "I hope dancers will take more ownership of their career and its prevention and will behave more like high-level athletes.

Vision

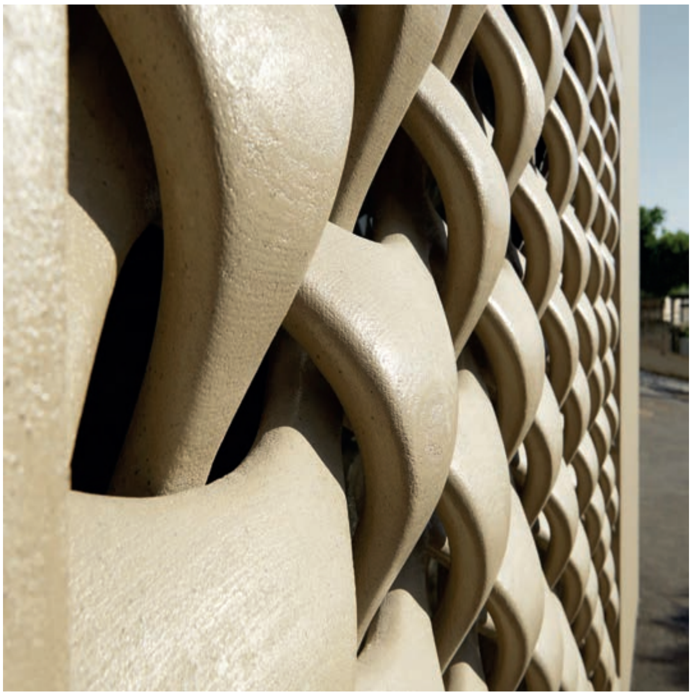
The product development takes place in close cooperation with dance medicinists and the TA.MED e.V. (Tanzmedizinischer e.v. Deutschland). From a health perspective, muscular training processes in particular can be significantly optimised through the new sole. A topic that is long overdue in ballet. Together with the Fraunhofer Institute IPA, a research series in the field of mass personalisation and motion analytics will be aimed. The aim is also to build the sole geometry parametrically in the future based on a generative design based on the dynamic forces. The focus of further development is on stress optimisation. For this purpose, a tool is to be used to optimise current predetermined breaking points in the future through stress analyses / topology optimisation and to identify stress peaks.

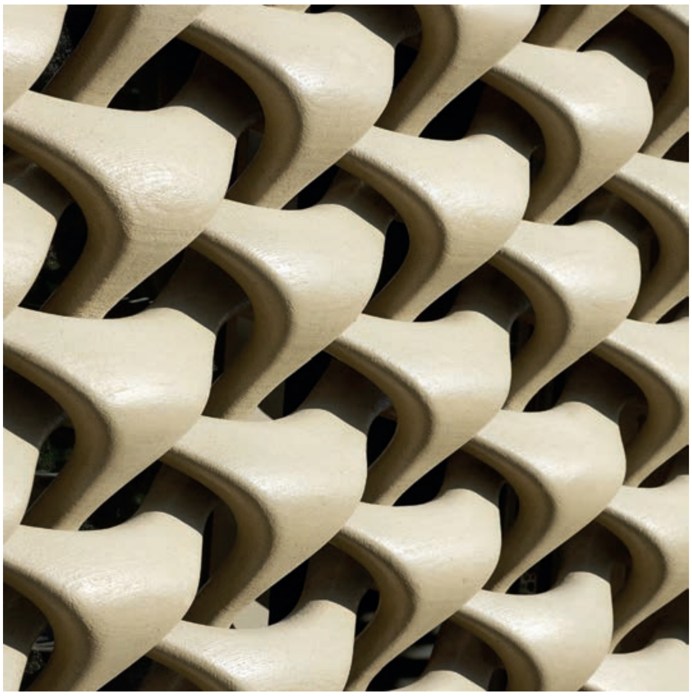
IP

trademark "act'ble" in: Switzerland, Canada, China, USA, Korea, Japan, Australia, Russia, Germany. Patent in EU and USA

Abraham Bonora - Studio für Architektur I Progress Group | Thomas Abraham | Ivan Bonora

Sun protection 3L



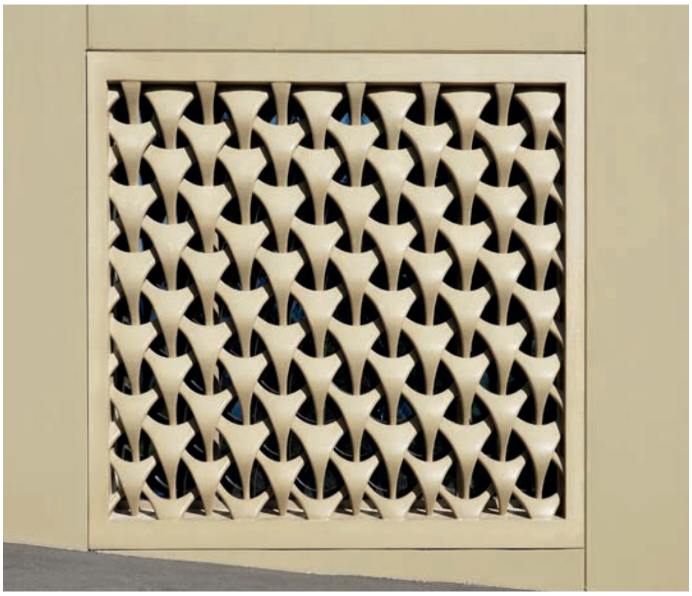


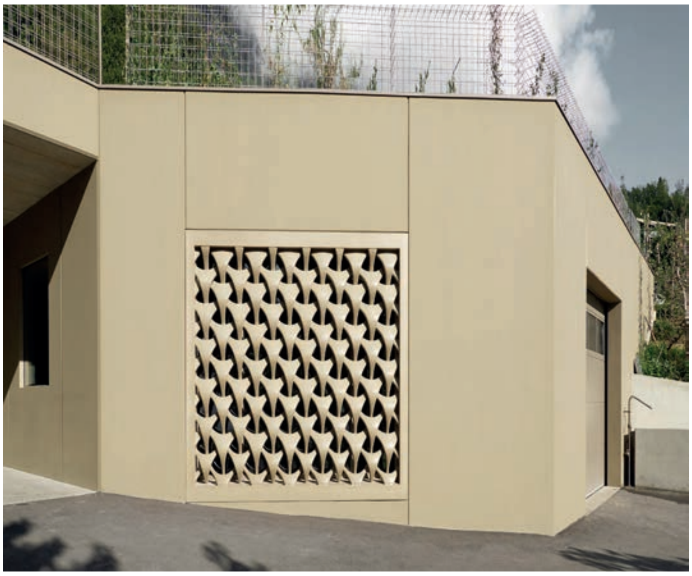
Description

The project is a garage with orangery built into the slope. This should be fitted with a large window opening and a fixed sun protection, which allows plenty of daylight into the room at any time of the year, but at the same time protects against direct sunlight. The challenge was to create a non-changing sun protection that nevertheless responds to the different position of the sun and the different radiation angles, to let enough or not too much light into the room all year round and at any time of the day.

Designed by Abraham Bonora, the 3D print consists of three scripted layers that are interwoven like a fabric. The parameter-based levels can be controlled by entering the position of the location and the related position of the sun over the course of a year, so that the shape and the resulting openings are changed in such a way that an optimal incidence of light is created.

In addition to this innovative parameter-based form finding, another new possibility of 3D concrete printing was also implemented. In order to bring the liquid material into shape, formwork is usually required. Free forms, especially interwoven structures, can only be implemented to a limited extent or with extremely great effort. Through the "weaving technique" used here, it is possible to give the usual solid material a light and freely flexible appearance, which gives the room a special and new character as part of the architecture.





The Manufacturing Technology Centre I Miguel Fernandez

Future of electric motors with AM

Design for Additive Manufacturing: Additive Manufactured electric motor

Investigating the state of the art to determine current constraints and development opportunities of additive manufacturing for electric motor components.

"The development of electric motors has not seen this level of focus for nearly 100 years despite being high on the priority list for many industry sectors that are seeking significant improvements in cost, quality, reliability and performance, in both gravimetric and volumetric terms. Systems engineering and integration – doing more with key components and materials - are key to achieving this and so Additive Manufacturing is a key enabler for developing complex features and forms, essential to improving the functionality and performance of electric motors, with singular and multi-materials solutions." Steve Nesbitt, Chief Technologist, MTC

The challenge

Additive manufacturing (AM) has been identified as an enabling manufacturing technology to produce power-dense electric motors in a repeatable and short lead time. Whilst additive manufacturing isn't new, its application for end-use parts and tooling has become more prevalent only in recent years, and is demonstrating its potential to change the way that products are designed and manufactured.

In academia, there are a growing number of research papers that highlight the benefits associated with an additive manufactured motor, however there are limited examples of AM in commercially developed products. The MTC's technology experts initiated a project that considered the wider implications of additive manufacturing for electric motors. The aim was to provide recommendations, based on existing limitations, for creating the next generation of electric machines.

MTC's solution

With support from the National Centre of Additive Manufacturing (NCAM) and the MTC's Electrification Steering Committee, the project team were able to identify the key challenges being faced by conventionally manufactured motors. Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL) assessments were conducted of additive manufacturing for key motor components. These assessments were combined with learnings from past projects and an analysis of present manufacturing techniques for each component. In doing so, the MTC was able to identify the current constraints and how, by, applying AM, these limitations may be resolved.

To demonstrate the potential benefits of leveraging the capabilities of AM, the cooling method of a commercial motor was reassessed, as a result of several iterations of a liquid-cooled motor casing.

The outcome

The benefits that AM can provide for each component of electric motors were identified, and a research and development roadmap was created to outline a route for progressing the implementation of AM in electric motors. Consequently, the MTC was able to propose new projects that can address the challenges and constraints of using additive manufacturing in electric motors.

The redesign of the casing by implementing liquidcooling channels allowed the motor to produce more power without overheating, a weight saving of 10% and size reduction of 30%.

Benefits to the industry

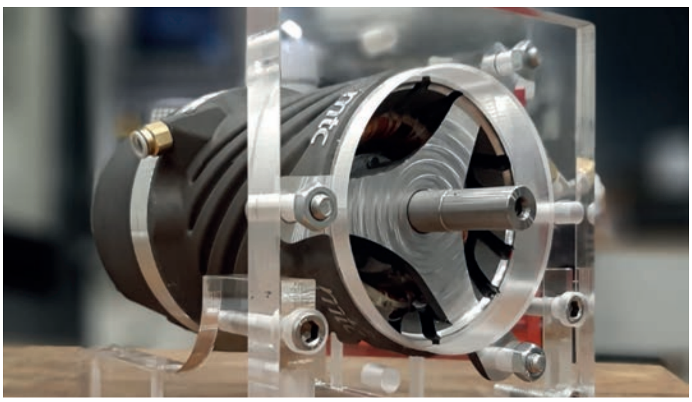
The process of manufacturing electric motors has a number of challenges to overcome; complex or manual assembly, materials that are difficult to process and can be rare and/or expensive, thermal management and lightweighting.

By leveraging the AM capabilities through the product redesign as demonstrated in the casing, key benefits were identified throughout the product and supply chain:

- Increased motor power density, resulting in a reduction in size and mass of key components
- Part count reduction, leading to simplified assembly and supply chains
- Increased manufacturing efficiency and reduced lead times
- Lower running costs
- Waste reduction
- Reduced assembly and inspection costs

The additive manufacturing motor roadmap provides a clear picture of the necessary developments required and potential challenges and constraints to introduce additive manufactured motors to industry.

"Additive manufacturing is complex, but the opportunities for businesses to improve their productivity, efficiency and cost savings – and therefore their competitiveness – are significant. This project has enabled us to identify a roadmap to support manufacturers with implementing AM technologies for electric motors, which has the potential to transform the industry as we know it." Dan Walton, Senior Research Engineer, MTC



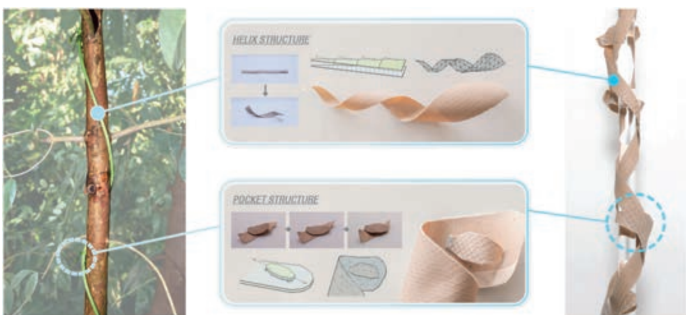
Institute for Computational Design and Construction (ICD) University of Stuttgart I Tiffany Cheng

4DmultiMATS: Bio-inspired 4D-printing of multifunctional material systems for self-adjusting wearable tech

Description

In nature, biological structures often adapt to their surroundings by changing shape and stiffness, sometimes completely passively and without using any energy at all. What if our engineered systems could behave like natural systems - and what are the potentials of doing so through additive manufacturing? The 4DmultiMATS project presents a design process that combines fused filament fabrication, material programming, and functional geometries from biology. This is demonstrated through a novel take on personalized and bio-inspired wearable devices for sports and medical applications, which can self-adjust in response to fluctuations in air humidity.

Nature offers a wealth of unexplored design strategies for encoding function and motion through structure. Through an interdisciplinary collaboration blending plant biomechanics, polymer chemistry, medicine, and computational fabrication, 4DmultiMATS investigates material programming for 4D-printing - that is, the design of the material and its behavior via choreographed paths of material deposition. This research project showcases how the twining and tensioning mechanism of a plant role model can be translated to technical systems, resulting in a personalized splint with adaptive reinforcement for increased wearing comfort.



Bio-inspired self-tightening | Technical transfer | 4D-printed mechanism

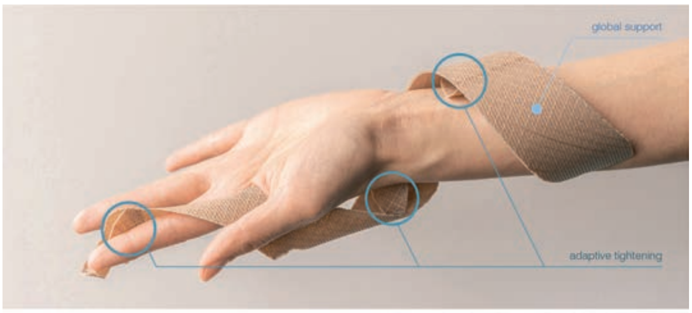
From plant to wearable tech

The twining vine Dioscorea bulbifera climbs by generating large squeezing forces on its host structure, allowing it to ascend great heights without slipping. This efficient and effective tensioning mechanism was transferred to 4D-printing by emulating the plant's motion sequence: first, loosely wrapping the helical structure around an existing support, and then expanding the discrete pocket structures (sparsely distributed on the inner surface of this helix) - thereby applying pressure to the support, pushing the helix outward, and tensioning the entire system.

Through controlled print paths using a standard desktop 3D-printer and commercially available filaments (including the moisture-reactive wood-polymer composite), the 4D-printed mechanisms were physically programmed to mimic the motion steps of D. bulbifera, and proven to generate forces in the same range as the plant role model. In fact, the inclusion of more expanding pocket structures (than occurring naturally in the plant) enabled the 4D-printed motion mechanisms to achieve even higher forces - demonstrating that computational design and 4D-printing can extend the performance and design space beyond the original bio-inspiration. As a use case, the function of self-tightening was prototyped in a wrist-forearm splint, a common orthotic device.

Future of additive innovations

Biomimetic 4D-printing opens up new possibilities for transferring nature's many untapped design principles, especially useful for mass-customized end products in the medical and sports industries. The accessibility of this technique, as well as the on-demand printability of adaptive and functional creations, lowers the barrier to accessing custom-fit solutions that provide comfort, support, and performance. This is illustrated in another highly customized orthosis that exhibits a tailored soft/stiff gradient, shape-changing areas for releasing pressure in sensitive zones when activated by sweat moisture, and an externally sourced alignment tool (embedded during the printing process) to produce the required amount of immobilization. Through its production flexibility, the 4DmultiMATS approach shows the potential of integrating multiple functionalities in one system - bringing our engineered designs one step closer to nature's.



For more information watch the videos: https://fb.watch/8bdS5F7FzA/ and https://vimeo.com/484468845

Tom Ayton // Aytonlab I Mack Next I Matthias Ocklenburg I Ralf Scheel I Moritz Waldemeyer I Dennis Gordt I Michael Heyse I Bas Van Rijsbergen I Tobias Eichinger I Marcus Ernst I Thomas Wagner I Sven Meyer

Yullbe - Mission Impossible

Description

In February 2020 TOM AYTON AYTONLAB was commissioned to realise an ergonomically correct full set of 54 suits for a completely new "Full body tracking Free roaming group experience" by Mack NeXT, the innovative division of Mack Rides (aka Europapark Rust).

In the YULLBE Experiences, groups of up to eight people solve challenges and experience their VR adventure together in a room of 300 square meter. You wear VR helmet, a backpack and hand and foot trackers so that you can move completely freely in the virtual world without cables.

Due to an extreme tight time schedule the only option left was to develop the product completely digitally and to rely heavily on the speed of 3D printing. But it was clear to even the most experienced product developer that this would be our biggest challenge yet according to Yullbe's motto: Get over the barriers of life!

The aim of the design was to make the technical equipment as imperceptible as possible, so that the user can concentrate on the immersive experience. The design of the YULLBE units is kept iconic/futuristic and the given hardware is combined as elegantly as possible into a whole.

The " design serves to minimise post processing during 3D printing and to avoid any tree chin effect. For this purpose, the plate like design is well suited to create a firm flexible upper structure that fits well to the helmet interior. The cracks in the structure allow stray light to pass through. The left right irregularly shaped joints also let air through very well and contribute to a rather cool head climate.

Contrary to its first appearance, the design of the helmet is a "one piece". The connecting bridges are on a lower offset level and make the panels appear to float, electronics elements are completely integrated.

Why? Simply because you we can do it that way in 3D printing.

Also the back unit, the hand and foot trackers are dimensioned in such a way that only eight EOS P 396 build volumes are needed for a full series of 54 suits. Due to the detailed design, the build time was optimised in such a way that in the end the target price for 3D print could even be undercut.

The YULLBE Experience successfully opened in September 2020. The project is proof for us, that 3D printing has a place in the fast lane of experimental product launches. The design is suited to get replicated many times soon.