IWBE 2021 QR web Link

IWBE 2021

International Workshop on Bionic Engineering 2021

16-17 September 2021 | Online

Programme & Proceedings

Welcome

Welcome to the 2021 International Workshop on Bionic Engineering (IWBE 2021) and the 4th International Workshop on Biorobotics & Bioengineering.

The IWBE 2021 aims to bring together worldwide researchers and leading scientists to discuss the cutting-edge development in the vigorous field of bionic engineering. This conference will cover the basic science underpinning bionic systems as well as the applied research in a myriad of exciting areas and stimulate discussions and exchange of ideas to better translate nature's inspiration to address grand challenges that we are encountering.

This conference is hosted by the University of Manchester, the International Society of Bionic Engineering (ISBE) and Jilin University.

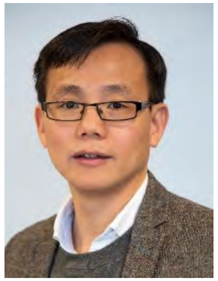
Due to the COVID-19 pandemic, the IWBE 2021 now fully goes virtual to take place on 16-17 September 2021, for the safety of all the delegates. We are fully committed to creating an excellent virtual conference - an online space to meet, network, and exchange knowledge in a safe and accessible manner.

We would like to express our sincerest gratitude to all the invited plenary and keynote speakers, and the authors who submitted the papers. Their high-quality work serves as the foundation for the success of this conference. The conference arranges presentations for all the 73 accepted papers in two parallel sessions, together with 3 plenary and 18 keynote presentations.

We gratefully acknowledge all the sponsors and benefactors for their contributions to this conference. In closing, we hope you will enjoy the invited and technical presentations, online networking, and all the interactive features provided through the online platforms of the IWBE 2021.

Conference Chair

Lei Ren, The University of Manchester



Program Chair

Guowu Wei, University of Salford

International Workshop on Bionic Engineering

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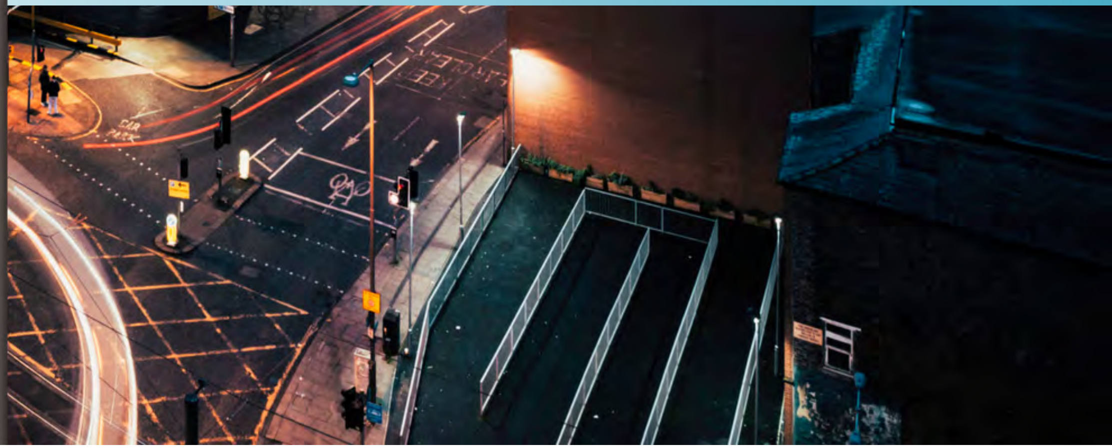

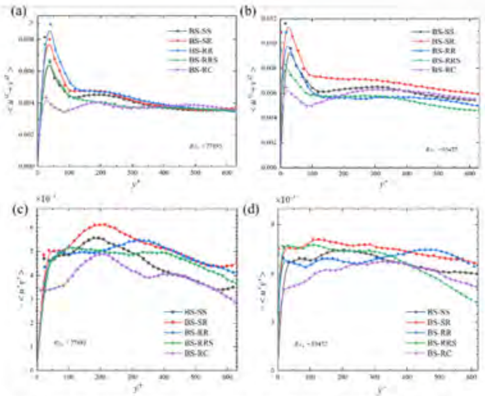

Figure 4. Reynold shear stress $< u'v' >$ of (a) $Re_b = 37129$ and (b) $Re_b = 44554$ in wall-normal direction. Turbulent kinetic energy $< u'^2 + v'^2 >$ of (c) $Re_b = 37129$ and (d) $Re_b = 44554$ in wall-normal direction.

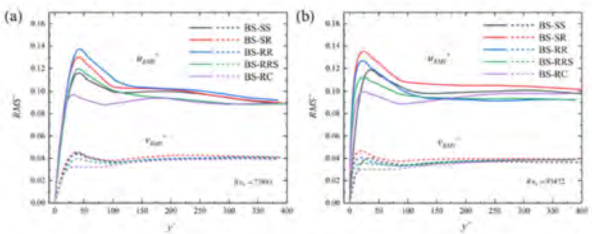

Figure 5. Root-mean-square (rms) of fluctuation velocity in wall-normal direction. ${u'_{rms}}^+$ and ${v'_{rms}}^+$ are normalized by U_∞. (a) $Re_b = 37129$ and (b) $Re_b = 44554$

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Abstract ID No.67

The Micromechanics of the Diatom Corethron Criophilum: An Experimental Study Utilizing 3D Printing

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Abstract

The micromechanics of the diatom Corethron criophilum have puzzled experts for decades. Uniquely among microorganisms, its silicate shell contains joints that allow hooked spines to move after cell division, until they have locked into a permanent resting position. Not only is the mechanism itself poorly understood, but the purpose of the spines themselves is also unknown. The complex structure of the joints has prevented researchers from accurately recreating the joints, while the nature of diatoms prevents observing many of the proposed purposes of the spines.

With 3D printing, this paper aims to test experimentally most of the hypotheses that have been brought forth since. Recreated from SEM and optical microscope images, the relevant parts were printed with a commercial fused deposition modelling (FDM) printer for testing. An FDM printer, like the Prusa I3 Mk3s used, deposits plastic filament from a heated nozzle. While not as detailed as stereolithography or powder bed printing, it allows for more material flexibility, like the transparent plastics essential for visualisation, or flexible materials that may or may not be required.

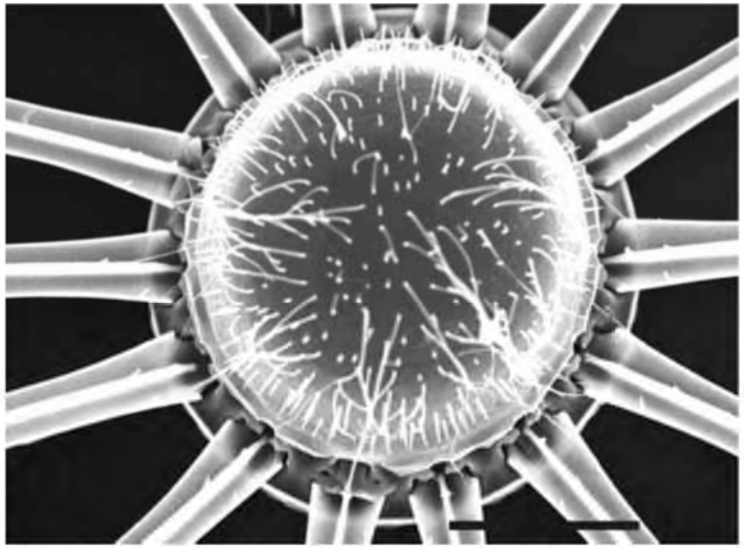

Figure 1: SEM image of a valve of *Corethron criophilum* in resting position, showing spines entering joints along valve circumference.

The most common explanation, suggested by Crawford and Gebeshuber [1][2], is that the joints contain some form of a click-stop mechanism to keep the joints locked after unfolding, while the hooked spines either lock the spines during cell growth to prevent twisting, or hold colonies together while maintaining enough distance to prevent overlaps. However, no click-stop can be found in microscope images, suggesting a friction-based one-way mechanism.

While the research is far from done, this unique organism might serve as a best practice example from nature on how to create joints with hard parts, especially when creating complex micromachinery such as MEMS.

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Abstract ID No.68

Design and Analysis of a Novel Bio-Inspired Tracked Wall- Climbing Robot with Flexible Spines

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Abstract

In order to improve the wall-climbing robot's applicability to the rough wall, a new type of bio-inspired tracked wall-climbing robot with flexible spines is proposed in this paper. Inspired by spines of some insects, a track with flexible spines mechanism is designed so that the robot can use it to hook on the rough surface of walls. Based on a lot of research on catch and detachment, a special track mechanism is designed to make it flexible to catch and detach from the surface. And several related simulation analyses have been carried out and the results turn out good. In addition, the statics and kinematics analysis of the robot during climbing process are also carried out. The robot prototype is developed and several climbing experiments and tests have been done. The results show that the tracked wall-climbing robot with flexible spines has good stability and can run at a desired speed on several different wall surfaces.

Figure 1: Insects with spines

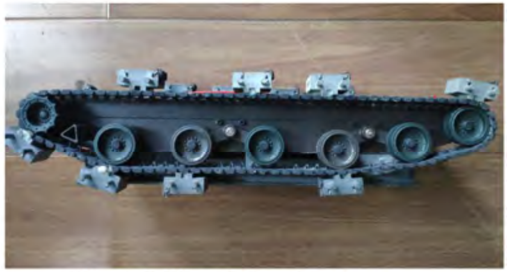

Figure 2: The robot prototype

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Abstract ID No.69

Structural Bactericide by Biomimetics of the Nanopillars on Cicada Wings

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Abstract

Recent studies show that the wings of certain insects such as cicadas and dragonflies reveal amazing properties. Not only are they super-hydrophobic and self-cleaning comparable to the famous lotus leaf, but also capable of actively killing bacteria [1]. The underlying mechanism is not a chemical bactericide, but tiny nanostructures that mechanically destroy the bacterial cells [2].

This study investigates the surface structure of two New Zealand cicada species (Amphipsalta cingulata and Kikihia scutellaris) with various methods such as AFM (Figure 1). The focus lies in investigating antibacterial structure properties via bacterial tests and establishing low-cost bioimprinting techniques ([3]) to transfer these structures to artificial surfaces, which would open a huge field of manifold applications such as hospital surfaces, medical instruments, smartphone displays and door handles. Since bacteria cannot develop resistance to physical structures as they do to chemical bactericides, this method would be of great advantage.

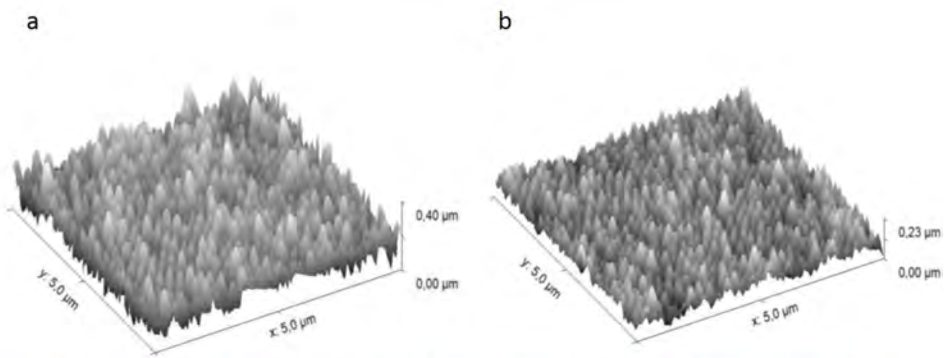

Figure 1 Three-dimensional reconstruction (AFM) of wing membrane surfaces of: a) *Kikihia scutellaris,* b) *Amphipsalta cingulata.*

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Abstract ID No.70

Biomimetic Passive Cooling

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Abstract

With the rise of the average global temperature due to the ongoing climate change, more and more households need a way of keeping their living environment at bearable temperatures. As it is a simple and seemingly effective method, many households invest in air conditioning. But air conditioning has a significant global environmental impact. Better long-term solutions might be passive cooling systems. This work explores possibilities of biomimetic passive cooling using structured surfaces. The focus is put on structures that, when applied on the surface of a body, can lower the average temperature of the body, compared to its temperature without the structured surface, without the need of electricity or replenishable resources. The physical principles enabling such cooling effects include the usage of shadow [1] and stimulated convection [2], total internal reflection [3], scattering [4], multilayer interference and diffraction [5], as well as enhanced emission via radiators [6]. When it comes to passive cooling even under direct sunlight, the increase of reflectivity and the decrease of absorption is important to reduce the gain of thermal energy from sunlight in the range from approximately 250 nm (UV) to about 2500 nm (IR) (Figure 1, yellow area). The other key point for effective daytime passive cooling is high emissivity in the infrared atmospheric window.

Earth's average temperature is at approximately 288 K, or roughly 15° C [7]. Its outgoing radiation (Figure 1, blue area) has its peak at a wavelength around 10 µm. As depicted in Figure 1, most of that radiation gets absorbed by the atmosphere which radiates part of that energy back to Earth, keeping it warm just like a blanket. But what is also observable in this picture is a hole in the absorption spectrum reaching from 8 to 13 µm, referred to as the infrared atmospheric window, which conveniently is right where Earth radiates the most. In this range, dry air is transparent and Earth and all bodies on Earth with a similar temperature can send their thermal energy out into space. [8] Instead of a high reflectivity, enhancing the absorptivity and thus the emissivity in this range increases the ability of a body to cool down.

Biomimetics, the abstraction of good design from Nature, helps to find novel non-polluting ways to achieve such cooling structures. Various examples for passive thermoregulation without evaporative cooling found in Nature will be explained in the presentation, focusing on fauna and flora in hot and arid regions. Possible attempts to use those with a breakdown of their environmental impact will be illustrated, differentiating between the effectivity in different habitats.

In conclusion it can be said that there are already great attempts for passive cooling, some even with a focus on sustainability. Yet more studies are needed, especially for large-scale production and usage. There is a lot to be learned from the beauty and expediency of living Nature. When it comes to optimizing technical cooling by inspiration from Nature, best practice examples range over various length scales and comprise a large variety of sometimes surprising organisms. Smart collaboration between experts from biology, engineering and further fields can pave the way towards innovative new applications with an added benefit of sustainable approaches.

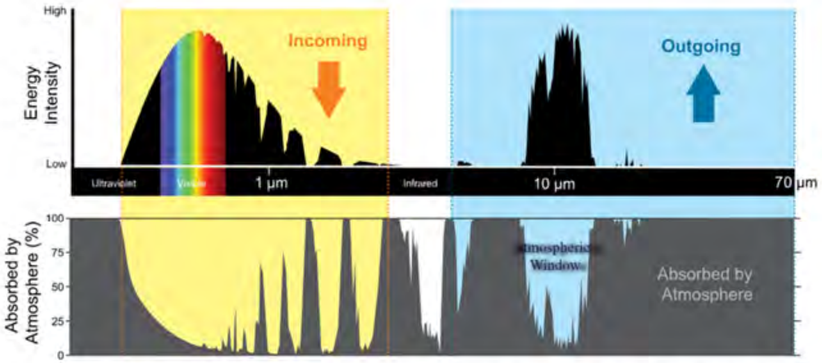

Figure 1: Top: Incoming energy from the sun and outgoing energy from the Earth relative to the wavelength. Bottom: Absorbance of the atmosphere relative to the wavelength. © National Weather Service [9]

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Abstract ID No.71

An active 3-DoF Soft Joint for Soft Robot Movement

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Abstract

Soft joint with multiple degrees of freedom (DoF) is crucial to dexterous movements of soft robots. For instance, the movements of wrist depend on the 3-DoF of flexion-extension(X-Y plane), radioulnar deviation (X-Z plane) and rotation (Z-axis). Similarly, in the design of neck, spine and many other parts in soft robots, multiple DoF soft joint are required. Unfortunately, current joint designs are based on elastic materials cannot actively produce multiple DoF and thus severely limit the movements of soft robots. This paper illustrates an active 3-DoF soft joint that is based on pneumatic soft actuator and combining with structure design (Figure 1a). It consists of four parallel soft cylindrical drive actuators adhere to each other. The four actuators have circle chambers and helical structures. The cross-section of the four connected rods displays four couples of concentric circles. Each soft actuator is composed of PDMS chamber, Kelar fiber and Ployester monofilament. The fiber winds the chamber along the helix grooves. The monofilament is adhere to the outer surface of the actuator along axial direction and is indicated by red colour at the cross-section inner area (Figure 1b). For each of the pressurized actuator, it produces a bending force and a torque with respect to the restraining layer (red line at the cross-section Figure 1b) [1]. For pressuring two of these chambers, bending or twisting actions can be obtained depends on combination results [2]. For instances, when pressuring channel a & b, the torques are off-set, and only leave the bending force with respect to the restraining layers which results bending actions (Figure 2(a&b)). When pressuring a & d, the bending forces are off-set, and only leave the torques which lead to twisting actions (Figure 2(a&b)) [3]. The total six actions for the 3Dof in accordance to pressurization of the different channels are listed in Table 1

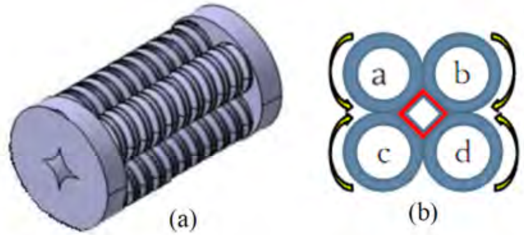

Figure 1: A soft hand with 3DoF wrist (a) 3D model (b) cross-section of the 3 DoF joint